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HIGH ENERGY PROPELLANTS

A CONTINUING BIBLIOGRAPHY WITH INDEXES

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HIGH ENERGY PROPELLANTS

A CONTINUING BIBLIOGRAPHY

WITH INDEXES

A Selection of Annotated References to Unclassified Reports and Journal Articles introduced into the NASA Information System during the period January through December, 1966.

Scientific and Technical Information Division
NATIONAL AERONAUTICS AND SPACE ADMINISTRATION
WASHINGTON, D.C. APRIL 1967

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(continued)

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Each entry in the bibliography consists of a citation and an abstract. The listing of entries is arranged in two major groups: all report literature references are contained in the first group and are arranged according to their date of announcement in *STAR*; the second group includes all published literature references arranged according to their date of announcement in *IAA*, or in *Aerospace Medicine and Biology*. All reports and articles cited were introduced into the *NASA* Information System during the period January through December, 1966.

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For further details please consult the *Introductions* to *STAR* and *IAA*, respectively.

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HIGH ENERGY PROPELLANTS

a continuing bibliography APRIL 1967

STAR ENTRIES

N66-14560# Battelle Memorial Inst., Columbus, Ohio.
DEVELOPMENT OF LAMINATED SOLID PROPELLANTS Final Technical Report 15 Apr. 1961–30 Nov. 1963
Alfred Rudnick, Robert A. King, James L. Harp, Delbert H. Fisher, Bailey Bennett et al 30 Nov. 1963 52 p
(Contract Nonr-3506(00)(FBM))
(G-4890-1; AD-622399) CFSTI: HC $3.00/MF $0.75

The concept of reinforcement of a solid-propellant grain through use of combustible metal or plastic laminates is discussed. Procedures used for preparing test samples for mechanical property studies and firing tests are described. Mechanical strength was found to be increased generally in proportion to the amount of reinforcement added. Firing tests demonstrated clearly that the orientation of the reinforcement layers parallel to the combustion surface is not compatible with satisfactory combustion, whereas, when the reinforcement is oriented normal to the combustion surface, buring is either enhanced or unchanged. Author (TAB)

N66-14706*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
INVESTIGATION OF BONDED PLASTIC TAPE FOR LINING FILAMENT-WOUND FIBER-GLASS CRYOGENIC PROPELLANT TANKS
Robert W. Frischmuth, Jr. and Paul T. Hacker Washington, NASA, Jan. 1966 48 p refs
(NASA-TN-D-3206) CFSTI: HC $2.00/MF $0.50 CSCL 11I

The use of filament-wound fiber-glass liquid-hydrogen propellant tank structures should result in a considerable weight savings compared to conventional metal tanks providing that a suitable internal liner can be developed. This report investigates the use of plastic tape liners bonded to the inner surface of the filament-wound structure. The compatibility of liners, made of Teflon and Mylar tape, with respect to the filament-wound shell was studied experimentally using liquid hydrogen and theoretically using an analytical technique derived in this report. The investigation shows for bonded liners used at the temperature of liquid hydrogen (normal boiling point 20° K) that Teflon is incompatible with the filament-wound structure and Mylar is limited; upon tank pressurization, the Mylar liner will fail in tension before the burst pressure of the filament-wound structure is approached. Author

N66-14707*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
INVESTIGATION OF THIN FILMS AS FLOATING LINERS FOR FIBER-GLASS CRYOGENIC PROPELLANT TANKS
Robert W. Frischmuth, Jr. Washington, NASA, Jan. 1966 31 p refs
(NASA-TN-D-3205) CFSTI: HC $1.00/MF $0.50 CSCL 11I

The use of filament-wound fiber-glass liquid-hydrogen propellant tank structures should result in a considerable weight savings providing that a suitable internal liner can be developed. This report investigates the use of free-floating liners. A theoretical analysis and experimental study on laminated Mylar, Teflon, and aluminum–Mylar liners showed that upon tank pressurization at liquid-hydrogen temperatures, plastic liners fabricated to the internal dimensions of the filament-wound structure would fail in tension before the burst pressure of the filament-wound shell was approached. The study showed that the available liner strain could be increased by making the liner oversized and allowing it to randomly wrinkle within the shell. Author

N66-14908*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
EXPERIMENTAL INVESTIGATION OF GLASS FLAKES AS A LINER FOR FIBER-GLASS CRYOGENIC PROPELLANT TANKS
Robert W. Frischmuth, Jr. Washington, NASA, Jan. 1966 17 p refs
(NASA-TM-X-1193) CFSTI: HC $1.00/MF $0.50 CSCL 11B

A method of lining a fiber glass tank with several layers of small, overlapping flakes of glass, interspersed in a resin and oriented parallel to the wall of the fiber glass shell, is discussed. In the fabrication technique developed, flakes of uniform size that passed through a 1/2-inch mesh screen were used; a thin coat of resin was sprayed on the mandrel; and a layer of glass flake was applied using a flocking gun. Six glass flake layers were used in the liner, with each layer rolled to force out air and excess resin and to insure proper orientation of the flakes. The liner was partially cured before winding the fiber glass shell to prevent slippage of the flakes, and no mold release was used. The liquid hydrogen test facility and procedure are described. Results indicate that the glass flake liner is thermally compatible with the filament wound shell; however, leakage prevented testing at a pressure greater than 1 atmosphere and no conclusion could be reached concerning strain compatibility Design details are also included on the mandrel, shell, and end fitting of the filament wound tank. M.G.J

N66-15018# Naval Ordnance Test Station, China Lake, Calif.
AUTOXIDATION OF 1,1-DIMETHYLHYDRAZINE

W. H. Urry, A. L. Olsen, E. M. Bens, H. W. Kruse, C. Ikoku et al (Chicago Univ.) Sep. 1965 40 p refs
(NOTS-TP-3903; NAVWEPS-8798; AD-622785) CFSTI: HC $2.00/MF $0.50

The autoxidation of 1,1-dimethylhydrazine I gives formaldehyde dimethylhydrazone II, nitrogen, and water as its major products. Minor ones are ammonia, dimethylamine, dimethylnitrosame, diazomethane, nitrous oxide, methane, carbon dioxide, and formaldehyde. This reaction is of first order in I and of zero order in oxygen. It is catalyzed by metals and metal salts, inhibited by added 1,3-butadiene, and accelerated by ultraviolet light. A free-radical chain mechanism is postulated as the rate-determining reaction sequency. The 1,1-dimethylhydrazyl-2-hydroperoxide so formed is presumed to give the products II, hydrazine, and hydrogen peroxide via a rapid sequency of wall reactions (established in the study of liquid-phase autoxidations of 1,1-dialkylhydrazines). Nitrogen and most minor products probably result from further wall reactions of hydrogen peroxide with I, II, and hydrazine. Autoxidations of hydrazine resemble those of hydrocarbons.
Author (TAB)

N66-15273*# Jet Propulsion Lab., Calif. Inst. of Tech., Pasadena.
STEADY STATE AEROTHERMOCHEMISTRY FOR LIQUID BIPROPELLANT ROCKET MOTORS
Vito D. Agosta and S. Z. Burstein 1 Oct. 1964 40 p *Its* Rept.-64.3
(Contract NAS7-100)
(NASA-CR-68846) CFSTI: HC $2.00/MF $0.50 CSCL 21B

A model is proposed for the combustion of a bipropellant spray in a rocket motor. The model includes three subsystems: the fuel droplets, the oxidant droplets, and the combustion gases. The fuel droplet ballistics are determined by assuming a diffusion controlled evaporating droplet; thus it follows that fuel vaporization serves as the rate-controlling combustion process. A Knudsen-Langmuir kinetic model is assumed for the evaporation of the oxidant droplets. The combustion gases are generated by the combustion of the evaporated propellants at the local O/F ratio. The solution to this problem requires solving the coupled equations for heat, mass and momentum transfer for the fuel and oxidant droplets and vapors, and combustion gases, and also the chemical equilibrium equations for varying oxidant–fuel ratio. One-dimensional compressible gas dynamics is assumed. The results of this analysis give the mass distribution of oxidant and fuel vaporization, and subsequent combustion, along the axis of the rocket motor. Author

N66-15280*# Thiokol Chemical Corp., Denville, N. J. Reaction Motors Div.
GELLING OF LIQUID OXYGEN FLUORIDE Final Report, 18 Nov. 1963–17 Nov. 1964
A. J. Beardell Dec. 1965 39 p refs
(Contract NAS3-4180)
(NASA-CR-54220; RMD-5039-F) CFSTI: HC $2.00/MF $0.50 CSCL 21I

A study was performed to gel liquid oxygen difluoride, to characterize the candidate system, and to determine its mechanical and chemical stability. Inorganic fluorides and oxides were screened as possible OF_2 gellants and Cab-O-Sil, a pyrogenic silica, was chosen as the candidate gellant. OF_2 was also gelled with Alon C and TiO_2 although the gels did not appear to be of comparable quality. The OF_2–Cab-O-Sil gel was evaluated for thermal stability, mechanical stability, evaporation rate relative to liquid OF_2 and shock sensitivity, and was shown to have satisfactory characteristics. Author

N66-15337*# Jet Propulsion Lab., Calif. Inst. of Tech., Pasadena.
AN EXPERIMENTAL CORRELATION OF THE NONREACTIVE PROPERTIES OF INJECTION SCHEMES AND COMBUSTION EFFECTS IN A LIQUID-PROPELLANT ROCKET ENGINE. PART VI: THE RELATION BETWEEN THE STARTING TRANSIENT AND INJECTION HYDRAULICS
Richard M. Clayton and Jack H. Rupe 29 Oct. 1965 29 p refs
(NAS7-100)
(NASA-CR-69251; JPL-TR-32-255) CFSTI: HC $2.00/MF $0.50 CSCL 21H

Starting flow transient criteria for gas-pressurized liquid bipropellant rocket engines are presented. These criteria are based on a consideration of the hydraulic characteristics of the propellant feed system, with particular emphasis on the propellant valve, the injector, and the injector-manifold volume. The desirability of a short starting transient without chamber pressure overshoot is presumed. A nonreactive testing technique is presented for the evaluation of the starting flow transient prior to the commitment of an engine to its initial firing. Results of the application of both the flow criteria and the nonreactive testing technique in an injection research program utilizing a 20000 lb thrust rocket motor are also presented. Author

N66-15358*# National Aeronautics and Space Administration. Marshall Space Flight Center, Huntsville, Ala.
SELF-SEALING SHIELDS FOR MICROMETEORITE PROTECTION
Erwin D. Funk 30 Dec. 1965 26 p refs
(NASA-TM-X-53376) CFSTI: HC $2.00/MF $0.50 CSCL 11B

Self-sealing shields for cryogenic propellant tanks are investigated. The self-sealing shields consist of a hexcel covering containing a porous media. The sealing occurs when the cryogenic propellant discharges and solidifies in the porous media which contains a vacuum. Two types of porous media are investigated, fiberglass strands and open cell polyester foam. The shields using polyester foam are shown to be a feasible method of solving the problems caused when a micrometeorite collides with a propellant tank. Author

N66-15490*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
MINIMUM PROPELLANT CONSUMPTION ROUND-TRIP TRAJECTORIES TO MARS FOR CONSTANT-THRUST, CONSTANT-SPECIFIC-IMPULSE VEHICLES WITH OPTIMUM COASTING PERIODS
Charles L. Zola and Laurence H. Fishbach Washington, NASA, Jan. 1966 34 p refs
(NASA-TN-D-3233) CFSTI: HC $2.00/MF $0.50 CSCL 20C

Propellant consumption data are presented for constant-thrust, low-acceleration, Earth-Mars round-trip trajectories including escape and capture spirals at both planets. Calculations are based on a previous analysis in which the calculus of variations was applied to the problem of minimizing the propellant consumption of the round-trip trajectory treated as a single unit. Solutions given are for initial accelerations between 1.0 and 4.0×10^{-3} meter per second squared and include optimum coast phases. Results for short trip times between 340 and 460 days and a long trip time of 1000 days are presented with various wait times at Mars. Also included are examples of mission profiles where the first and/or last Earth spirals are deleted. A simple example is given showing how data of the type presented may be used for mission analysis. The mission profiles and their data are limited in scope because of computational difficulties. These results, therefore, are not sufficient for a complete study of the Mars round-trip mission.
Author

N66-15532# Wissenschaftliche Gesellschaft für Luft- und Raumfahrt, Cologne (West Germany).
REPORT OF THE MEETING OF THE PROPELLANT RESEARCH BOARD ON 3 DECEMBER 1964 IN TRAUEN/SOLTAU [BERICHT UBER DIE SITZUNG DES FORSCHUNGSAUSSCHUSSES TREIBSTOFFE AM 3. DEZEMBER 1964 IN TRAUEN/SOLTAU]
A. Dadieu 1 Oct. 1965 76 p refs In GERMAN
(DLR-65-10) CFSTI: HC $3.00/MF $0.75

The following topics were discussed: (1) *Lithergolic Propellants*—basic problems, and future developments and application possibilities; (2) *Combustion in Lithergol Rocket Engine*—experiments with nitric acid as oxidizer; (3) *Hypergolization of Solid Fuels by Nitric Acid, respectively, Dinitrate Tetroxide in Nitric Acid*; and (4) *Lithergolic Combustion Reactions of Lithium Hydride with Fluorite.* Transl. by G.G

N66-15702# Atlantic Research Corp., Alexandria, Va. Kinetics and Combustion Group.
RESEARCH ON THE DEFLAGRATION OF HIGH-ENERGY SOLID OXIDIZERS Quarterly Technical Summary Report No. 13, Jan. 1–Aug. 31, 1965
J. B. Levy and G. von Elbe 11 Oct. 1965 13 p refs
(Contract AF 49(638)-1169)
(AD-624533) CFSTI: HC $5.00/MF $0.50

The flame temperature of hydrazine diperchlorate was measured using fine Chromel-Alumel thermocouples. At 28 atm the measured temperature was found to be > 200° C below the calculated product gas temperature. The observed temperature increased with pressure, and at approximately 100 atm the theoretical value is attained. The temperature profile through the preheat zone of the combustion wave was carefully measured at 18 atm. This was found to agree well with that predicted by theory if some variation of thermal diffusivity with temperature is assumed. The thermal profile at low pressure was found not to exhibit the character of that of a normal deflagration wave. This finding has shed considerable light on the nature of the process. Finally, quenching experiments were performed and these are discussed. Author (TAB)

N66-15716# Idaho Univ., Moscow.
NEW HYPOFLUORITES CONTAINING NITROGEN Quarterly Technical Report No. 6
Jean'ne M. Shreeve 1 Jan. 1965 5 p
(Contract Nonr-4217(00); ARPA Order 442)
(AD-624641) CFSTI: HC $1.00/MF $0.50

The fluorination study of trifluoronitrosomethane in the presence of a AgF_2 catalyst has now been completed. Conditions of concentration, time of irradiation, and other experimental conditions were varied in an attempt to obtain as high a yield of NF_2COF as possible from the irradiation of CO and N_2F_4. In a continuation of attempts toward the preparation of nitrogen-containing hypofluorites, preparation of some perfluoro compounds which could be used as starting materials were investigated. TAB

N66-15770*# Peninsular ChemResearch, Inc., Gainesville, Fla.
DEVELOPMENT OF VULCANIZABLE ELASTOMERS SUITABLE FOR USE IN CONTACT WITH LIQUID OXYGEN Second Annual Summary Report, 9 May 1964–8 May 1965
Paul D. Schuman 8 Jun. 1965 146 p refs
(Contract NAS8-5352)
(NASA-CR-69544; CPB-02-1163-63) CFSTI: HC $4.00/MF $1.00 CSCL 11J

Selected references have been compiled concerning polymer structure as related to thermal properties with major emphasis placed on fluorine containing polymers. Glass transition temperature as related to polymer structure is discussed. Several new monomers have been prepared: $CF_3OCH = CF_2$, $CF_3OCF = CHF$, $(CF_3O)_2C = CF_2$ and $SF_5OCF = CF_2$. Elastomeric copolymers have been prepared from $CH_2 = CF_2$ and the first three monomers. Transition temperatures of a number of polymers have been determined by DTA and the extension of our present knowledge concerning structure–thermal properties relationshp is discussed. The previously unreported CHFBrCHFBr was synthesized. Optimum conditions for the preparation of CF_3OF, COF_2 and $(CF_3O)_2$ have been determined. $(CF_3O)_2$ has been added to $CFCl = CFCl$ to give mainly telomers. An attempt to prepare $(CH_3O)_2C = CF_2$ and $(CF_3CH_2O)_2C = CF_2$ by the Wittig synthesis was not successful. Reaction of $(CF_3)_2C = O$ with C_2F_4 in the presence of CsF gave a low conversion to a complex liquid mixture. A low molecular weight siloxane polymer $\{C(CF_3)_2OSi(CH_3)_2O\}_x$ and a poly(carbonate), $\{OCH_2(CF_2)_3CH_2OCO\}_x$ were prepared. Attempts to prepare C_2F_5OF by reaction of AgF_2 with CF_3COF and by indirect reaction through the intermediate $CF_3OOC_2F_5$ were not successful. An attempt to prepare $CsOCF_3$ resulted in only limited success. Author

N66-15771*# Southwest Research Inst., San Antonio, Tex. Engineering Analysis Section.
SOME NOTES ON LIQUID SLOSHING IN COMPARTMENTED CYLINDRICAL TANKS Technical Report No. 1
H. Norman Abramson, Luis R. Garza, and Daniel D. Kana 15 Feb. 1962 19 p refs
(Contract NAS8-1555)
(NASA-CR-69545) CFSTI: HC $1.00/MF $0.50 CSCL 20D

As one relatively simple means of avoiding dynamic coupling between sloshing of liquid propellants and automatic control system response, or elastic body response, it has been suggested that propellant tanks be compartmented so as to raise or otherwise modify the normal sloshing frequencies. There is also the possibility of an overall reduction in the total force response as a result of phasing of the liquid motions in different compartments. Frequencies are also increased in the case of clustered tank configurations (over that for a single tank of the same capacity), but the weight penalty is more severe and additional complications may be introduced through other dynamic coupling effects. The present paper gives some results of experimental studies of frequencies and total force response in rigid tanks compartmented into sectors by vertical walls and excited in translation. These data are correlated with theoretical values, where available. Some theoretical values for cylindrical tanks with annular cross-sections are also shown for comparative purposes. Author

N66-16000# Atlantic Research Corp., Alexandria, Va. Kinetics and Combustion Div.
RESEARCH ON THE DEFLAGRATION OF HIGH-ENERGY SOLID OXIDIZERS Quarterly Technical Summary Report, 1 Dec. 1963–29 Feb. 1964
R. Friedman and J. B. Levy 6 Jul. 1964 31 p refs (Declassified)
(Contract AF 49(638)-1169; ARPA Order 332-62)
(Rept.-7; AD-351940)

Measurements of vaporization rates, deflagration rates, temperature profiles in the deflagrating strands, and flame temperatures are presented for hydrazine perchlorate. Except in the presence of small amounts of fuel or catalyst additive, the deflagration of pure hydrazine perchlorate is erractic and nonreproducible. Reproducibility is attainable only between

1/4 and 7 atms. It is concluded that at higher pressures the liquid layer becomes too thin to support the contribution of the condensed-phase reaction necessary for stable deflagration. Preparation and processing of the hydrazine perchlorate are discussed along with strand preparation and sublimation experiments. M.W.R.

N66-16049*# Stevens Inst. of Tech., Hoboken, N. J. Dept. of Mechanical Engineering.
SURFACE EFFECTS OF FLAME SPREADING OVER IGNITING COMPOSITE SOLID PROPELLANTS CONSTITUENTS
Fred A. Horowitz, Suh Yong Lee, and Robert F. Mc Alevy, III
Jun. 1965 57 p refs
(Grant NGR-31-003-014)
(NASA-CR-69695; ME-RT-65005) CFSTI: HC $3.00/MF $0.50 CSCL 21B

An experimental investigation was made of the mechanism by which a flame spreads over the surface of igniting composite solid propellant constituents. The velocity of flame spreading over the surface of polystyrene and polymethylmethacrylate in quiescent, oxidizing gas environments, and over the surface of ammonium perchlorate in a quiescent, fuel-gas environment was measured as a function of pressure level, chemical nature and reactivity of the surrounding environment, and specimen surface conditions. The effect of surface geometry was studied by employing test specimens of loosely packed beads, hydraulically pressed beads, chemically bonded beads, and smooth surfaced solids. These specimens were prepared and mounted in a relatively large vacuum tight chamber, and following ignition by means of an electrically heated wire, the velocity of flame spreading was measured cinematographically. It was found that velocities vary directly with pressure level, and that when surface geometry factors are introduced there is a marked increase in the velocity and a departure from theoretical predictions. C.T.C.

N66-16153*# Jet Propulsion Lab., Calif. Inst. of Tech., Pasadena.
FILL VALVE DEVELOPMENT FOR THE ADVANCED LIQUID PROPULSION SYSTEM (ALPS)
W. F. Mac Glashan, Jr. 1 Feb. 1966 27 p refs
(Contract NAS7-100)
(NASA-CR-69918; JPL-TR-32-875) CFSTI: HC $2.00/MF $0.50 CSCL 21H

A simple, compact, lightweight valve was developed to satisfy the need for reliable fill valves for the Advanced Liquid Propulsion System (ALPS). Manually operated valves for on-off control of Earth-storable propellants and inert gases were designed, built, and tested. The preferred valve design consists of a ceramic ball, a screw, and a tank boss. The screw pushes the ball onto a spherically lapped seat in the tank boss. With the ground fitting engaged, the valve can be actuated irrespective of line pressure. Flow can be either around or through the screw. Several variations of this ball valve are described. Problems encountered, refinements, and test results are discussed. Author

N66-16155*# National Aeronautics and Space Administration. Marshall Space Flight Center, Huntsville, Ala.
EFFECTS OF VARIOUS ADDITIVES ON PHYSICAL PROPERTIES AND PERFORMANCE OF MONOMETHYLHYDRAZINE
Harold Perkins 3 Nov. 1965 18 p refs
(NASA-TM-X-53356) CFSTI: HC $1.00/MF $0.50 CSCL 21I

The freezing and boiling points of 0–40% mixtures of various nitrogen compounds and water in monomethylhydrazine (MMH) were determined experimentally. The additives for these mixtures were selected on the basis of chemical similarity to MMH, mixture thermal stability, probability of contamination occurrence, cryoscopic and ebullioscopic effects, and anticipated effects on propellant performance. Theoretical specific impulses were calculated as a function of additive concentration using nominal values of the Saturn S-IVB Vehicle Auxiliary Propulsion System motor as a basis. Based on the results of these studies, N,N-dimethylformamide and water appear to be the most suitable additive for increasing the liquid range of MMH without degrading its performance. Author

N66-16157*# National Aeronautics and Space Administration. Marshall Space Flight Center, Huntsville, Ala.
1965 PUBLICATIONS BY MATERIALS DIVISION
13 Jan. 1966 25 p refs
(NASA-TM-X-53378) CFSTI: HC $1.00/MF $0.50 CSCL 05B

A compilation of annotated abstracts of NASA technical memorandums and MSFC internal notes written by personnel of the Materials Division and released during 1965 is presented. Publication topics covered include material studies in propellants; bonded composite materials; engineering materials; alloys; elastomers; organic materials; explosives; lubricants; and heat carrying materials. L.S.

N66-16265# Dynamic Science Corp., Monrovia, Calif.
COMBUSTION INSTABILITY Final Technical Report
[1962] 77 p refs
(Contract AF 49(638)-1151)
(SN-1800; AFOSR-65-1683; AD-623847) CFSTI: HC $3.00/MF $0.75

The principle objective of the program was to relate combustion stability to injector design variables through a consideration of droplet dynamics and combustion. The basic model treats the individual droplets as energy and mass sources. Stability or instability is determined by the relationship between energy and mass addition and the characteristics of the chamber or of a disturbance introduced into the chamber. Depending upon such relationships, a disturbance will be either amplified or dumped. A determination of the stability of a system will depend not only upon the frequency response of the energy and/or mass source but may also depend upon its spatial relationship. One of the first efforts in the study was to determine whether propellant droplets would assume specific patterns with respect to a disturbance and whether these patterns could affect the stability of the combustion process. TAB

N66-16455*# Rocketdyne, Canoga Park, Calif.
CHAMBER TECHNOLOGY FOR SPACE-STORABLE PROPELLANTS
E. V. Zettle, R. W. Riebling, and S. D. Clapp [1965] 55 p Presented at the AIAA Joint Propulsion Specialists Conf., Colorado Springs, 14–18 Jun. 1965
(Contract NAS7-304)
(NASA-CR-70014) CFSTI: HC $3.00/MF $0.50 CSCL 21H

Analytical and experimental studies were conducted towards establishing the technology necessary for the design of cooled thrust chambers capable of an 1800-second firing duration at a minimum c* efficiency of 95 percent, using the high performance oxidizer, oxygen difluoride, in a hydrazine-type fuel, and a thrust chamber configuration was selected that consisted of an ablative combustion chamber, a regeneratively cooled throat section, and an ablative nozzle skirt. The analyses also defined the optimum chamber pressure and mixture ratio to be used experimentally. Experimental firing tests at the 1,000 pound thrust level provided specific design criteria for a cooled thrust chamber using the selected propellant combination. Several candidate injector designs were evaluated, and a self-impinging doublet pattern was found to be the most compatible with the selected chamber cooling concept. The thrust chamber components (ablative chamber, regeneratively cooled throat, and ablative skirt) were fabricated and evaluated under sea level and simulated altitude conditions. The results indicate that all of the components can be expected to maintain their structural integrity for the required 1800-second duration while providing a c* efficiency of at least 95 percent. L.S.

N66-16677# American Oil Co., Whiting, Ind. Research and Development Dept.
THE FO RADICAL AND PRESSURE REACTIONS OF N_2F_2 Eleventh Quarterly Report, 1 Aug.–1 Nov. 1965
A. Zletz et al Nov. 1965 54 p refs
(Contract DA-31-124-ARO(D)-78; ARPA Order 402)
(M65-265; AD-624928) CFSTI: HC $3.00/MF $0.50

Efforts to generate gaseous OF centered upon flash photolysis of CF_3COOF at low temperature. Two transient phenomena were found: at 77°K violet phosphorescence from the solid and at higher temperature two diffuse absorption bands from the gas. Because the phosphorescence is observed from the solid of several fluorocarbonyl compounds, the phosphor is likely an impurity excited by energy transfer from the host lattice. For electrolytic generation of OF_2 from wet HF, ohmic overvoltage at the nickel anode was determined by both potential decay and superimposed square wave. The ohmic overvoltage at normal electrolysis conditions was surprisingly low (0.25 to 0.40 V at 4.8 V anode). Work continued on the structure of N_2F_2 complexes. Solutions of N_2F_5 in SBF_5, blue when fresh but rapidly fading to yellow, were examined by electron paramagnetic resonance to determine if the color arises from free radicals. An EPR spectrum of the yellow solution could be resolved into two separate spectra. The sixteen-line spectrum is consistent with the SBF_5 (−) radical while the five-line spectrum arises from an N_2 containing radical of as yet unknown composition. TAB

N66-16746*# Jet Propulsion Lab., Calif. Inst. of Tech., Pasadena.
SOME DESIGN CONSIDERATIONS, LARGE EXPULSION BLADDERS FOR NITROGEN TETROXIDE AND HYDRAZINE
A. J. Bruman 15 Jan. 1966 38 p refs
(Contract NAS7-100)
(NASA-CR-70034; JPL-TR-32-862) CFSTI: HC $2.00/MF $0.50 CSCL 21H

The problems of chemical compatibility, permeation and folding of bladders are discussed in the context of the requirements of the Advanced Liquid Propulsion Systems (ALPS). An extensive review of the literature on subjects pertinent to these problems is summarized. Several experiments are described in which bladder materials were permeated by the fuel and oxidizer, and the meaning of the results discussed. Folded paper models illustrating some attempts to find a scheme for collapsing bladders in a controlled manner are shown; none were found suitable for the ALPS application. Three appendixes review the status of knowledge concerning oxidization resistance and permeation of polymers and the nature of Teflon. A lengthy bibliography and list of references are included. Author

N66-16938*# National Aeronautics and Space Administration. Marshall Space Flight Center, Huntsville, Ala.
EXPERIMENTAL AND ANALYTICAL STUDIES OF CRYOGENIC PROPELLANT TANK PRESSURANT REQUIREMENTS
M. E. Nein and J. F. Thompson Washington, NASA, Feb. 1966 111 p refs
(NASA-TN-D-3177) CFSTI: HC $4.00/MF $0.75 CSCL 21H

The extensive requirement for pressurization of cryogenic propellant tanks of launch and space vehicles has directed attention to the need for accurate methods of analysis of propellant tank thermodynamics. This paper presents the results of experimental and analytical studies of pressurization gas requirements for cryogenic liquids. Experimental results are analyzed for cylindrical and spheroidal tanks ranging in size over four orders of magnitude. A parameter study of the controllable variables of a pressurization system design illustrates their effect on ullage gas temperature. Pressurization data are provided for use in the development or checkout of analytical pressurization models and for design of pressurization systems for future launch and space vehicles. A tank pressurization computer program, using recommended coefficients, can be used to predict total and transient pressurant requirements and ullage temperature gradients within 10 percent accuracy. Author

N66-16960# Atlantic Research Corp., Alexandria, Va. Kinetics and Combustion Div.
RESEARCH ON COMBUSTION IN SOLID ROCKET PROPELLANTS. HYDRAZINE NITROFORM AS A PROPELLANT INGREDIENT Final Technical Report
G. von Elbe, R. Friedman, J. B. Levy, and S. J. Adams 21 Jul. 1964 26 p refs
(Contract DA-36-034-AMC-0091(R))
(AD-352186) (Declassified)

Deflagration rates were determined at pressures of 3 to 1000 psia for granular nitroform (HNF) tamped into glass tubes. Rates were found to be independent of tube diameter, to increase linearly with pressures above 20 psia, and to be independent of pressure at low pressures. Quenching occurred below a critical tube diameter ranging from 0.3 cm at 2 psia to 0.01 cm at 1000 psia. Deflagration wave width was about seven times the ratio for thermal diffusivity to linear deflagration width; thermal diffusivity of the unreacted material being 0.001 cm^2/sec. Chemical deflagration began with the melting of HNF, and this is attributed to the spontaneous formation of nucleate centers of pyrolysis throughout the fused material. Initially these centers are microbubbles of gaseous decomposition material products, notably NO_2, which reacts with the ambient fused material. Nitroform is unstable well below 120° C, around its melting point, and decomposes to release NO_2; and there are more of these molecules generated than destroyed by the reaction. M.W.R.

N66-17045*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
WALL AND BOTTOM HEATING OF LIQUID HYDROGEN IN A PROPELLANT TANK
Sidney C. Huntley, James W. Gauntner, and Bernhard H. Anderson Washington, NASA, Feb. 1966 35 p refs
(NASA-TN-D-3256) CFSTI: HC $2.00/MF $0.50 CSCL 20M

An experimental investigation was made to determine the behavior of liquid hydrogen in a 125-gallon scale model of a propellant tank subjected to a range of wall heat flux from 0.0012 to 0.0082 Btu per square foot per second and a range of bottom heat flux from 0.0005 to 0.0098 Btu per square foot per second while discharging from the tank at a rate of 0.04 pound per second under a constant tank pressure of about 2 atmospheres. Increasing temperature stratification in the liquid was encountered with increasing wall heat flux; a decrease in stratification was experienced with increasing bottom heat flux. An available analysis partially predicted the increase in temperature stratification. Generalization of the exit temperature histories showed that the data were applicable to other test conditions provided similarity existed in the normalized heat input rate distribution. Application of the generalization method to other test data showed that bottom heating gave results similar to nuclear heating from below which had a similar overall heat input rate distribution. No gross changes in liquid behavior were experienced over the range of experimental conditions. Author

N66-17076*# Martin Co., Denver, Colo.
STUDY OF CONTAMINATION OF LIQUID OXYGEN BY GASEOUS NITROGEN First Quarterly Report, 1 Jul.–30 Sep. 1964
Dale A. Fester, Philip J. Pizzolato, and John R. Wilde Oct. 1964 41 p refs
(Contract NAS8-11337)
(NASA-CR-70311; CR-64-51 (Issue 3)) CFSTI: HC $2.00/MF $0.50 CSCL 21H

A preliminary analytical model for the system was developed which takes into account the applicable heat and mass transfer mechanisms. An existing tank pressurization computer program is being modified to incorporate both the transfer processes in the analytical model and property data for liquid and gaseous oxygen and nitrogen over the wide range of conditions being studied. Of particular concern was the development of expressions for the transport properties of the ullage gases at pressure levels above the critical pressure. Most of the desired expressions were developed and excellent correlation with experimental data was obtained. A description of the test system, tests planned, and test procedure is presented together with the program schedule. Author

N66-17077*# Lockheed-Georgia Co., Marietta. Nuclear Lab.
STUDY OF FUNDAMENTALS OF PRESSURANT DISTRIBUTOR DESIGN Final Report
Jan. 1966 124 p
(Contract NAS8-5416)
(NASA-CR-70304; ER-8275) CFSTI: HC $4.00/MF $1.00 CSCL 21H

The results of an analytical and experimental study of pressurant distributor design fundamentals are presented. The results of expulsion tests employing gaseous nitrogen over liquid nitrogen clearly show that a means of limiting the velocity with which condensable pressurants impinge on the liquid surface is required if massive condensation is to be avoided. An analysis of turbulent free convection heat transfer is presented. Curves of Grashof number, characteristic velocity, and heat transfer coefficient are presented for gaseous hydrogen, oxygen, helium, and nitrogen all at 30 psia. A computer program used to generate some of the free convection data is included along with a sample case. An analysis of forced convection is made on the basis of the radial wall jet. Theoretical and experimental investigations of the radial wall jet have shown that the maximum velocity in the jet decreases rapidly with distance while the entrainment of secondary fluid increases quite rapidly. Rigimesh screen was found to have a much higher strength-to-weight ratio than any other material tested. Multiple radial distributors are shown to be lighter than a single distributor when total active surface area and internal pressure are the same. Author

N66-17098*# Florida Univ., Gainesville. Dept. of Engineering Science and Mechanics.
RESEARCH INVESTIGATIONS OF BULKHEAD CYLINDRICAL JUNCTIONS EXPOSED TO COMBINED LOAD, CRYOGENIC TEMPERATURES AND PRESSURE. PART I: EXPERIMENTAL STUDIES
C. A. Sciammarella Nov. 1965 109 p refs
(Contract NAS8-5199)
(NASA-CR-70326) CFSTI: HC $4.00/MF $0.75 CSCL 20K

The objective of this study is the experimental analysis of one design version of an aft-bulkhead-connection ("Y-ring section") of a Saturn V S-IV lox container. Two different sections are contained in the report. The first section deals with a two-dimensional analog model built to study the bending stresses of the "Y-ring." Two experimental stress techniques were applied in this study. The Moire method was utilized to measure displacements. Photoelasticity was used to measure possible stress concentration effects. The second section of the report deals with the study of a 1/6 reduced scale model of the tank. Strain-gauges and displacement transformers were applied to the model to measure strains and displacements. Results of the reduced scale model show very good agreement between the theoretically computed stresses and the stresses determined in the model. Author

N66-17904*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
SIMULATED NUCLEAR HEATING OF LIQUID HYDROGEN IN A PROPELLANT TANK
Sidney C. Huntley and James W. Gauntner Washington, NASA, Mar. 1966 30 p refs
(NASA-TN-D-3328) CFSTI: HC $2.00/MF $0.50 CSCL 21I

An experimental study was made to simulate nuclear heating of liquid hydrogen in a propellant tank by using an electrical immersion heater and radiant heaters. Flow tests were made in a 125-gallon tank pressurized to 2 atmospheres with a flow rate of about 0.04 pound per second. Test results showed that the inoperative immersion heater did not alter the exit temperature history. Operation of the immersion heater tended to result in a more completely mixed liquid than existed with nuclear heating. A comparison of bottom (radiant) heating with nuclear heating showed a nearly identical generalized exit temperature history with a similar generalized heat input rate distribution and equal heating parameters, although the initial total heat input rates varied by a factor greater than 6. High bottom (or liquid source) heating was observed to consistently result in a liquid disturbance near the surface during the transient development of a temperature gradient. Author

N66-18022*# Atlantic Research Corp., Alexandria, Va.
STUDY OF PROPELLANT VALVE LEAKAGE IN A VACUUM PHASE I REPORT, 7 JUN.–24 NOV. 1965
Ralph D. Gift, John A. Simmons, Joseph P. Copeland, and Jack M. Spurlock [1965] 117 p refs
(Contract NAS9-4494)
(NASA-CR-65225) CFSTI: HC $4.00/MF $0.75 CSCL 21H

A study is being conducted on propellant valve leakage and the resultant freezing and blockage of propellant flow systems when propellants are exposed to a vacuum environment. This report investigates the phenomena associated with various leakage and freezing situations using N_2O_4. A theoretical analysis was made to predict the limiting N_2O_4 leak rates for freezing in the propellant manifo' ' and injector of the Apollo SPS engine. The lower limit leak rate of N_2O_4 for the SPS engine is predicted to be 180 cc/hr. Leak rates below this value present no flow blockage problem. The maximum leak rate is predicted to be 450,000 cc/hr. Although rates above this value will not cause flow blockage, a serious hazard would result because of propellant accumulation in the combustion chamber prior to ignition Experimental results agreed closely with theoretical predictions. Measurements made before and after each test, in which freezing occurred, showed that the torque required to open the leak valve was unaffected even when the N_2O_4 froze in the vicinity of the leak valve ball or stem. Flow delays, due to propellant freezing between the leak valve and injector plate, were observed on 41 of the 85 tests conducted. R.N.A.

N66-18158*# Marquardt Corp., Van Nuys, Calif.
HYDROGEN RELIQUEFIERS FOR LUNAR STORAGE SYSTEMS
T. A. Sedgwick, R. Mc Glone, and A. Malek 12 Mar. 1964 98 p refs *Its* Rept.-6033
(Contract NAS8-5298)
(NASA-CR-70531) CFSTI: HC $3.00/MF $0.75 CSCL 21H

General criteria are developed for the application of reliquefiers to eliminate propellant boil off losses in space and lunar storage systems. Combination of these criteria with conservative estimates of the mass and performance of reliquefiers for liquid hydrogen storage systems at lunar equatorial sites indicates the following: for a storage duration of 12 lunar days (approximately one earth year) the total masses which must be transported to supply a fixed mass of liquid hydrogen at the end of the storage period can be reduced 14 and 28 percent by the use of reliquefiers for 20 and 10-foot diameter storage tanks, respectively. Operation of these reliquefiers only during the lunar night results in unvented tank pressure increases during the daylight hours of only 5 and 12 psi, respectively, and is, therefore, considered feasible. This mode of operation permits the reliquefiers waste heat to be radiated to space using comparatively low radiator temperatures. This in turn permits the use of relatively simple reliquefier cycles which could not otherwise be employed. Preliminary reliquefier component analysis and design studies tend to substantiate the initial reliquefier mass and performance estimates. Author

N66-18168*# National Aeronautics and Space Administration. Goddard Space Flight Center, Greenbelt, Md.
IMPULSE AND THRUST TEST OF A SUBLIMATING-SOLID MICROPROPULSION SYSTEM
Richard W. Forsythe Washington, NASA, Mar. 1966 26 p
(NASA-TN-D-3245) CFSTI: HC $2.00/MF $0.50 CSCL 21H

An integrating microthrust balance was utilized to evaluate the impulse and thrust performance characteristics of a rocket system which employs a new concept for propulsion; that is, it effects a controlled thrust from the sublimation of a solid propellant. The propulsion package tested was designed to provide thrust in a control system of a spin stabilized satellite. Author

N66-18324*# Georgia Inst. of Tech., Atlanta. Engineering Experiment Station.
STUDY FOR IMPROVEMENT OF GROUND TEST, INSTRUMENTATION SYSTEMS, AND METHODS—NEW METHODS FOR STAGE PROPELLANT TANK PROOF TESTING Final Report, 2 Apr.–1 Dec. 1965
John H. Burson, III 1965 56 p refs
(Contract NAS8-20110)
(NASA-CR-70583) CFSTI: HC $3.00/MF $0.50 CSCL 21H

The objective of this research program was to develop high-density slurries suitable for use as pressure-transmitting media in hydrostatic testing of stage propellant tanks. This included a determination of the range of densities that could be obtained; determination of mixture stabilities; determination of compatibility with stage and stage component materials; and the definition of pumping, storage, and other handling techniques. Water-based slurries were formulated from a large number of materials and it was conclusively shown that specific gravities from two to six could be achieved with readily available materials and conventional chemical processing equipment. Lead oxide (litharge) was shown to be the most suitable material for producing stable slurries over a wide range of specific gravities. Laboratory data indicate that these slurries also act as pressure transmitting media. A preliminary economic analysis favors the construction of an on-site plant for producing slurries in quantities of up to one million gallons. Author

N66-18465*# General Dynamics/Astronautics, San Diego, Calif.
LIQUID RESPONSE TO AN ORIENTATION MANEUVER
30 Jul. 1962 35 p refs *Its* Rept.-550-859-7
(NASA-CR-54497) CFSTI: HC $2.00/MF $0.50 CSCL 20D

This report describes an investigation of the effect of the Centaur orientation maneuver on the liquid fuel. A justification for model testing is presented with scaling equations and the results of preliminary tests. The main tests used a 1/90th scale tank model and a trajectory determined from the scaling equations. The behavior of the model contents is described and mathematically analyzed. The simulated fuel was appreciably (but not violently) disturbed. We conclude that the LH_2 will not be seriously disturbed by the 180° maximum turn although there remains some possibility that a more gentle maneuver might produce a more drastic effect. A center vent should be usable soon after the orientation, perhaps in 300 seconds. Author

N66-18504# Monsanto Research Corp., Dayton, Ohio.
STUDIES OF LOW-TEMPERATURE OXIDATION REACTIONS Annual Progress Report, Oct. 1, 1964–Sep. 30, 1965
L. Parts and J. T. Miller, Jr. 6 Dec. 1965 60 p refs
(Contract Nonr-3977(00))
(APR-3; AD-625307) CFSTI: HC $3.00/MF $0.75

Nitrosonium nitrate, $NO^+NO_3^-$, is formed upon the oxidation of nitric oxide in certain hydrocarbon solutions at cryogenic temperatures. The infrared spectrum of this compound was studied at temperatures ranging from 79° to 205° K. Low-temperature (77°–90° K) oxidative nitration of isobutylene and subsequent oxidation of the unstable product with N_2O_4 at 273° K yield 2-nitratoisobutyraldehyde and 2-nitratoisobutyric anhydride. Nitrosonium nitrate may be transitory intermediate in the reaction of N_2O_4 with olefins at about 273° K. Tetraflurohydrazine was found to react with a number of inorganic and organometalloid compounds. Most of these reactions occur only above 243° K. This suggests that the difluoramino radical, present in equilibrium with tetrafluorohydrazine in this temperature range, is the reactive species. TAB

N66-18945# Oak Ridge National Lab., Tenn.
SYNTHESIS AND INFRARED ABSORPTION SPECTRUM OF DIBORANE-^{10}B
H. L. Holsopple and Lucy E. Scroggie 19 Feb. 1965 8 p refs
(Contract W-7405-ENG-26)
(ORNL-TM-1061) CFSTI: HC $1.00/MF $0.50

Essentially pure diborane-$^{10}B(^{10}B_2H_6)$ was prepared for the Physics Division. The compound was prepared by the incremental addition of $^{10}BF_3$-etherate to a diethyl ether solution of lithium aluminum hydride. The product was purified by fractional condensation, and its purity was established from its infrared absorption spectrum and mass spectroscopic analysis. Author (NSA)

N66-19031*# Aerojet-General Corp., Sacramento, Calif.
DEVELOPMENT OF LIQUID OXYGEN COOLED 110 MM ROLLER AND TANDEM BALL BEARINGS AT UP TO .5 x10^6 DN VALUES FOR THE OXIDIZER TURBOPUMP OF THE M-1 ENGINE Technology Report
M. W. Young and L. F. Kirby 11 Mar. 1966 88 p refs
(Contract NAS3-2555)
(NASA-CR-54816; AGC-8800-23) CFSTI: HC $3.00/MF $0.75 CSCL 13I

A development program for the purpose of evaluating the suitability of the bearing package designed for the M-1 liquid oxygen turbopump was completed. The test results indicate that the bearing performance is adequate as compared with that predicted during the design phase. The 110 mm roller and tandem ball bearings were demonstrated at $.5\times10^6$DN values, radial loads of 15,000 lb and thrust loads up to 70,000 lb (twice the rated load). Liquid oxygen and liquid nitrogen were used as coolants; bearing materials were 440C stainless steel with armalon cages. Author

N66-19172*# Atlantic Research Corp., Alexandria, Va.
STUDY OF PROPELLANT VALVE LEAKAGE IN A VACUUM Phase IV Report, 10 Dec. 1965–14 Jan. 1966
Ralph D. Gift, John A. Simmons, Joseph P. Copeland, Jack M. Spurlock, and Jaydee W. Miller 17 Feb. 1966 84 p refs
(Contract NAS9-4494)
(NASA-CR-65237) CFSTI: HC $3.00/MF $0.75 CSCL 21H

Adverse effects of evaporative freezing of propellant in the manifolds of the Gemini 25-pound and 100-pound orbit attitude maneuvering system (OAMS) rocket engines are described. The investigation consisted of a theoretical analysis of evaporative freezing of propellant in the injector manifolds of the OAMS engines, and an experimental study of flow stoppages caused by such freezing. Preliminary data show: (1) Leading nitrogen tetroxide can freeze evaporatively and obstruct flow in the oxidizer manifolds, but monomethylhydrazine cannot. (2) The residual propellant in the manifold after engine shutdown does not obstruct subsequent propellant flow. (3) Obstructions created by evaporatively frozen nitrogen tetroxide caused either a delay in the initiation of flow and/or a delay in achieving full flow after the valve was opened. It was decided that sufficient data are not available to establish conclusively the seriousness of the freezing effect on the Gemini spacecraft performance. N.E.N.

N66-19440# Auburn Univ., Ala. Depts. of Chemistry and Chemical Engineering.
A STUDY OF THE DECOMPOSITION MECHANISM OF AMMONIUM PERCHLORATE Quarterly Report, Jun. 1–Sep. 30, 1965
James E. Land [1965] 17 p
(Contract DA-01-021-AMC-12346(Z))
(QR-1; AD-625191) CFSTI: HC $1.00/MF $0.50

The research is concerned with the study of the chemical changes that occur during the decomposition of ammonium perchlorate (hereinafter abbreviated AP) produced by the application of heat. To follow the exo- and endothermic changes which are produced when AP is heated from ambient temperature to approximately 450°C., the technique of differential thermal analysis (DTA) is used. Interest is centered at present on the effect of various catalytic agents on the mechanism of AP decomposition. During the period of this report efforts continued with the making of DTA runs at various heating rates on AP samples to which had been added various materials to test the catalytic effect of these additives. TAB

N66-19457*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
REACTION CHARACTERISTICS OF SPILLS OF FLUORINE AND FLUORINE-OXYGEN MIXTURES UPON VARIOUS MATERIALS
Louis M. Russell, Harold W. Schmidt, and Robert F. Clarke Washington, NASA, Mar. 1966 23 p refs Film Supplement No. C-243 to this report is available on loan from Lewis Research Center
(NASA-TN-D-3118) CFSTI: HC $0.25/MF $0.50 CSCL 21I

Small quantities of liquid fluorine, liquid oxygen, and liquid 30-percent FLOX were spilled upon various common materials which might be found or placed around a rocket test or launch facility for the purpose of investigating hypergolicity and other reaction characteristics. When fluorine or 30-percent FLOX is spilled upon many of these common materials, sufficient hypergolic reaction can occur to create a combustive hot spill. The hot spill creates a rapid high cloud rise, which provides efficient diffusion and dispersion of the toxic products and tends to reduce the potential downwind ground-level pollution. The reactions varied from smooth-burning reactions to strong detonations; the variation depended upon whether FLOX or fluorine was spilled and upon which materials they were spilled. Spills of liquid fluorine or FLOX upon materials with which they do not react combustively resulted in typical cryogenic cold spills in which the toxic vapors drifted downwind close to the ground and thus created high pollutant concentration for a considerable distance downwind. The desirable characteristics of the FLOX-charcoal reaction indicate that the placement of charcoal in areas of possible fluorine or FLOX spills could provide effective spill and pollution control. Author

N66-19647*# Boeing Co., Seattle, Wash. Aero-Space Div.
INVESTIGATION OF THE FEASIBILITY OF FLOX FOR PERFORMANCE IMPROVEMENT ON THE S-IC
M. E. Schlapbach 31 Dec. 1964 293 p refs
(Contract NAS8-5608)
(NASA-CR-70720; D5-11464-1; TAO-22) CFSTI: HC $6.00/MF $1.50 CSCL 21I

The payload of the Saturn V vehicle can be increased up to 65 percent by using 70 percent Liquid Fluorine and 30 percent Liquid Oxygen (FLOX) as the oxidizer on the S-IC. This would require moderate changes to the engine and stage. By using essentially the existing engines and the stage, the payload can be increased approximately 38 percent. Implementation of FLOX on the S-IC will require minor stage material changes and redesign of some items to minimize contaminant traps since fluorine reacts with most contaminants. A passivation procedure may be used to minimize contaminant reaction. Toxic exhaust cloud problems exist; however, investigation indicates general feasibility. A fairly sophisticated launch or test area weather sampling network fed into an appropriate computer system for continuous cloud behavior predictions would probably be required before large scale use of FLOX on the S-IC could be implemented. Launch time restrictions can be expected under certain weather conditions. Storing and handling of FLOX would require modifications and additions to the ground support equipment. Author

N66-19672# Library of Congress, Washington, D. C. Aerospace Technology Div.
LIQUID AND SOLID PROPELLANTS TECHNOLOGY Surveys of Communist World Scientific and Technical Literature
Edward Wolski 7 Jan. 1966 160 p refs Compilation of abstracts
(ATD-66-2)

Abstracts from the Soviet literature on liquid propellants, solid propellants, high energy fuels, advanced energy sources, and combustion are presented. A total of 214 entries from 53 journals and 15 books are annotated. E.E.B.

N66-19691*# General Dynamics/Convair, San Diego, Calif.
PRELIMINARY DESIGN STUDY: OXIDIZER TANK HELIUM PRESSURE REGULATOR, FLOX-ATLAS, AIRBORNE Final Report
D. L. Gray, D. E. Howard, and A. M. Colvin 24 Sep. 1965 123 p refs
(Contract NAS3-3245)
(NASA-CR-54878; GD/C-BJB65-008) CFSTI: HC $4.00/MF $1.00 CSCL 14B

Four design approaches were successively pursued for the FLOX Atlas regulator. The first two designs contained unique features which lent themselves to a direct acting regulator. As it became increasingly apparent that some means of amplification would be required, these approaches were abandoned. The third approach contained more sophisticated features which provided the force amplification necessary to achieve the designed accuracy and still maintained the regulators physical size within reasonable parameters. The fourth approach incorporated further improvements over the third, and fulfilled the design requirements. The most important features of the design are as follows: (1) Certain sections, such as the shutoff valve, were taken from existing designs which have been fully developed. (2) For stable operation, a device is incorporated to change the regulation gain when inlet pressure decreases to 2000 psi. (3) The gain change device also accomplishes a programmed pressure change in tank pressure. (4) No dynamic seals are used. (5) Leakage is reduced by assembling the high pressure components from the lower pressure side. (6) All shutoff functions and desired low leakage paths incorporate poppet-type devices. Author

N66-19692*# General Dynamics/Convair, San Diego, Calif.
PRELIMINARY DESIGN OF A FLOX DISCONNECT FOR A FLOX-ATLAS VEHICLE Final Report
L. E. Siden, A. P. Traskell, and R. H. Anderson 13 Sep. 1965 158 p refs
(Contract NAS3-3245)
(NASA-CR-54877; GD/C-BHV65-004) CFSTI: HC $5.00/MF $1.00 CSCL 21H

This report presents the results of a study program to establish a preliminary design of a multiple purpose disconnect for use in a FLOX-Atlas oxidizer system. Design requirements are defined, current technology is reviewed, and a selected valve design is presented and installed in three locations. Author

N66-19693*# General Dynamics/Convair, San Diego, Calif.
PRELIMINARY DESIGN STUDY: OXIDIZER TANK RELIEF VALVE, FLOX-ATLAS AIRBORNE Final Report
D. L. Gray, C. W. Aulgur, and A. M. Colvin 21 Sep. 1965 99 p refs
(Contract NAS3-3245)
(NASA-CR-54876; GD/C-BJB65-009) CFSTI: HC $3.00/MF $0.75 CSCL 13K

Two separate design philosophies for protecting the FLOX-Atlas oxidizer tank against overpressurization were studied. One approach, the use of the boiloff valve for venting at a high pressure, was abandoned when extensive modifications became apparent. The second system of adding a smaller (2 3/4 line size) valve for relief at maximum tank pressure proved to be more acceptable. Three different designs were studied and one was recommended for use. Author

N66-19962# Auburn Univ., Ala. Dept. of Chemistry.
A STUDY OF THE DECOMPOSITION MECHANISM OF AMMONIUM PERCHLORATE Quarterly Report, 1 Oct.–31 Dec. 1965
James E. Land [1966] 11 p
(Contract DA-01-021-AMC-12346(Z))
(QR-2; AD-626805) CFSTI: HC $1.00/MF $0.50

Efforts were concerned with: (a) a continuation of the making of DTA runs at various heating rates on ammonium perchlorate (AP) samples to which had been added various metal oxides to measure the catalytic effect of these additives; (b) performing DTA runs on AP samples to which had been added certain metal complexes of the ferrocene type, and (c) beginning a series of DTA runs on AP samples which have been doped with a known per cent of a metal perchlorate so as to determine the influence of this additive on the DTA exo- and endotherums recorded for AP decomposition as it is heated at various rates over a given temperature range. Author (TAB)

N66-20151# Frankford Arsenal, Philadelphia, Pa. Quality Assurance Directorate.
DETERMINATION OF CARBON BLACK AND GRAPHITE IN NITROCELLULOSE-BASE PROPELLANTS
Goerge Norwitz and Michael Galan Nov. 1965 39 p refs
(T66-3-1; AD-627253) CFSTI: HC $2.00/MF $0.50

The entire problem of determining carbon black and graphite in nitrocellulose-base propellants was investigated. It is shown that available methods for the determination of carbon black leave much to be desired, especially if carbon black and graphite are both present. A new spectrophotometric method for the determination of carbon black in propellants is proposed that depends upon the yellow color obtained when carbon black is dissolved by boiling with nitric acid. Improved gravimetric procedures are proposed for the determination of graphite in nitrocellulose-base propellants by the morpholine, nitric acid, and nitric-hydrochloric acid methods. Also described is an improved procedure for the determination of graphite and tin on the same sample. The results obtained for all the methods for graphite are compared. TAB

N66-20442# Los Alamos Scientific Lab., N. Mex.
ANALYSIS OF SHOCK WAVE AND INITIATION DATA FOR SOLID EXPLOSIVES
J. B. Ramsay and A. Popolato [1965] 5 p refs Presented at the 4th Symp. on Detonation, Silver Spring, Md.
(Contract W-7405-ENG-36)
(LA-DC-6992; CONF-651003-3)

If the usual analysis of shock-wave data is made for polycrystalline plastic-bonded HMX and pressed TNT, the experimental data extrapolate to the detonation pressure point rather than to the peak spike pressure point. This is indicative of a reactive wave, which is to be expected. Limitations based on the assumptions and analysis are discussed to show that it is not possible to infer any information about the shock properties of unreacted explosive from the available shock-wave data for solid explosives. Since no calculational model is available which will permit the computation of the details of initiation of solid explosives, empirical relationships are presented to summarize the data for engineering purposes. Author (NSA)

N66-20530# California Univ., Livermore. Lawrence Radiation Lab.
THE DEVELOPMENT OF PLASTIC BONDED EXPLOSIVES
Edward James 29 Apr. 1965 15 p Presented at the Am. Ordnance Assoc., Propellants and Explosives Sect. Meeting, Yorktown, Va.
(Contract W-7405-ENG-48)
(UCRL-12439-T; CONF-650516-1) CFSTI: HC $1.00/MF $0.50

The development of a PBX is based on formulating principles emobyding considerations of performance, handling and

operational sensitivity, chemical and thermal stability, physical or mechanical properties and manufacturing. The history of the development of several important PBXs, 9007, 9407, 9010, 9404, and LX-04-1, is presented along with a discussion of the formulating considerations used to arrive at the final composition. Comparative properties are presented along with suggestions of application in different ordnance items. PBX 9404 is an example of an explosive in which energy density is maximized and so is highly brisant; PBX 9407 is very sensitive to shock initiation and so is important for booster applications.
Author (NSA)

N66-20719 Aeronutronic, Newport Beach, Calif. Applied Research Labs.
THERMODYNAMIC PROPERTIES OF PROPELLANT COMBUSTION PRODUCTS Quarterly Letter Report No. 1, 1 Jun.–31 Aug. 1965
N. D. Potter [1965] 8 p refs
(Contract AF 49(638)-1577; ARPA Order 317)
(QLR-65-14; AFOSR-65-2295; AD-625044) CFSTI: HC $1.00/MF $0.50

The objective of the program is to provide thermodynamic data for species which are potentially important combustion products of advanced chemical rockets and for species which are related to these. Enthalpy and entropy data are obtained from equilibrium measurements made by torsion free evaporation and torsion effusion techniques and by high temperature mass spectrometry.
TAB

N66-20808# Martin Co., Baltimore, Md. Research Inst. for Advanced Studies.
THEORETICAL AND QUANTUM CHEMISTRY OF N, O, F COMPOUNDS Quarterly Technical Report, 9 Oct. 1965–9 Jan. 1966
Joyce J. Kaufman [1966] 26 p refs
(Contract DA-31-124-ARO(D)-203; ARPA Order 542)
(QTR-7; AD-626184) CFSTI: HC $2.00/MF $0.50

The objective of the research is to investigate the theoretical and quantum chemistry of energetic N, O, F compounds with the aim of providing understanding of the fundamental bonding and behavior of these species. The goal is to establish the validity of and the criteria for using various theoretical techniques for the prediction of pertinent properties of these compounds. A new molecular SCF program is being written to replace the POLYATOM program. The chain which evaluates all integrals arising from d orbitals was rewritten. Calculational results by a modified three-dimensional 'extended Huckel' LCAO-MO procedure show good agreement with the experimental behavior and properties of O and OF compounds. Bond energies, bond lengths, infrared frequencies, ionization potentials, absorption spectra and fluorinating power all correlate well with the calculational results for overlap populations and energy levels.
TAB

N66-20827# California Univ., Los Angeles. School of Medicine.
1, 1-DIMETHYLHYDRAZINE EFFECTS ON CENTRAL EXCITATORY AND INHIBITORY MECHANISMS IN CATS Final Report, Jan. 1964–Jun. 1965
M. D. Fairchild and M. B. Sterman Wright-Patterson AFB, Ohio, ARML, Aug. 1965 41 p
(Contract AF 41(609)-2329)
(AMRL-TR-65-142; AD-623786) CFSTI: HC $2.00/MF $0.50

Experiments, using cats with chronically implanted brain electrodes, were performed to explore the influence of subconvulsive doses of 1, 1-dimethylhydrazine (UDMH) on certain excitatory and inhibitory mechanisms in the central nervous systems (CNS). The cats were stimulated electrically in the midbrain reticular activating system, the basal forebrain inhibitory area, and both areas simultaneously while the animal was tested for performance in a positively reinforced experimental situation. UDMH was compared with amphetamine, chlorpromazine and phenobarbital both in the presence and absence of CNS stimulation. UDMH acted in a manner similar to chlorpromazine in subconvulsive doses in these tests. The most interesting and consistent effect of UDMH was to abort performance when the basal forebrain inhibitory area was stimulated. The animals resumed performance when the stimulus was terminated. UDMH has detectable CNS effects at doses well below convulsive levels.
Author (TAB)

N66-20867*# Lockheed Missiles and Space Co., Sunnyvale, Calif.
DEVELOPMENT OF THERMAL PROTECTION SYSTEM FOR A CRYOGENIC SPACECRAFT MODULE Monthly Progress Report, No. 19, 31 Dec. 1965–31 Jan. 1966
(Contract NAS3-4199)
(NASA-CR-71165) CFSTI: HC $1.00/MF $0.50 CSCL 22B

Work progress on the development of a thermal protection system for a cryogenic spacecraft module included a ground-hold test on the half-scale module. Preliminary test data indicated that the surface temperatures of the purge substrate were below nitrogen liquification temperature. Hydrogen boil-off rates decreased with time from about 64 pounds per hour to about 40 pounds per hour, after six hours. An orbital heat-flux simulation test to evaluate the insulation system under vacuum conditions found an equilibrium hydrogen boil-off rate of 0.65 pound/hour.
G.G.

N66-21001*# Monsanto Research Corp., Everett, Mass. Boston Lab.
STUDY OF FUEL CELLS USING STORABLE ROCKET PROPELLANTS Final Report, 28 Jan. 1964–29 Jan. 1965
J. C. Orth, L. F. Athearn, R. E. Chute, R. F. Drake, R. Havlin et al 9 Mar. 1965 351 p refs
(Contract NAS3-4175)
(NASA-CR-54640; MRB5007F) CFSTI: HC $7.00/MF $1.75 CSCL 10A

Fuel cells are described that operate with storable rocket fuels as reactants. Electrodes were developed and demonstrated for N_2H_4 and H_2 fuels and HNO_3, N_2O_4, O_2 and ClF_3 oxidizers. A full cell of the type $N_2H_4/KOH/O_2$ was operated for over 2285 hours at 25° C, 100 ma/cm^2, with a voltage of 0.6–0.7 v. Oxygen pressure was one atmosphere absolute. Another full cell of the type $N_2H_4/H_3PO_4/N_2O_4$ was operated for over 645 hours at 60° C, 100 ma/cm^2, with a voltage of 0.65–0.75 v. System designs for 1-kW units using these cells were developed. Both units were 1.3 ft^3 in volume, the alkaline-O_2 unit had an indicated weight of 45 lb; the acid-N_2O_4 system weight was 67 lb. Ion exchange membrane cells were investigated. A N_2H_4/ion exchange membrane/HNO_3 cell with both reactants dissolved in H_3PO_4 was operated for 30 hours at 60°C and 100 ma/cm^2 with a voltage of approximately 0.5 v. The feasibility of steam reforming unsymmetrical dimethyl hydrazine and monomethyl hydrazine to a H_2-rich (43 mole-%) feed stream for a fuel cell was demonstrated.
Author

N66-21013*# Vickers Inc., Troy, Mich. Research and Development Dept.
DESIGN AND DEVELOPMENT OF AN INTEGRATED SIXTY POUND THRUST CHAMBER Final Report
J. A. Berst and M. Mudryk 24 Apr. 1963 203 p
(Contract NAS9-554)
(NASA-CR-65308; TR-2-8) CFSTI: HC $6.00/MF $1.25 CSCL 21H

Detailed reports on the design and development of an integrated pulse modulated thrust chamber that produces a thrust of 60 lb±3% when operated continuously are presented. A response of less than 0.010 sec measured from the time rated current is applied to the solenoid to the instant the output thrust equals 80% of rate thrust, was achieved. It was determined that nitrogen tetroxide should be the oxidizer; that the fuel should be a 50/50 mixture of hydrazine and UDMH; that the combustion chamber pressure should be 150 psia; that the inlet pressure to the injector valve should be 240 psia; that the pressure differential across the propellant injector should be 75 psi; that the efficiency of the combustion chamber should be about 95%; that the minimum pulse bit attainable be 0.60 lbs-sec; that the pulse rocket be designed for minimum weight and size compatible with a high degree of reliability; and that the electrical power to operate the solenoid should be 17 watts maximum. Other design recommendations are also made, based on materials and components testing. Calibration curves, instrumentation, and schematic diagrams are given. Gas to liquid leakage conversion; vacuum equipment; and solenoid and linkage train parameters are also described. L.S.

N66-21075*# Boeing Co., Seattle, Wash. Space Div.
VOYAGER SPACECRAFT SYSTEM. VOLUME C: ALTERNATE DESIGNS CONSIDERED FOR SPACECRAFT PROPULSION SYSTEMS Final Technical Report, Task B
Jan. 1966 245 p Prepared for JPL
(Contracts NAS7-100; JPL-951111)
(NASA-CR-71510; D2-82709-8) CFSTI: HC $6.00/MF $1.50 CSCL 21H

Candidate concepts considered were solid/liquid systems sized both for the 1971 and 1973 missions and the 1975 and 1977 missions, the Apollo Lunar Excursion Module descent propulsion system, and the Titan III-C transtage. Propulsion system tradeoffs and analyses leading to a selection of the preferred propulsion design for the Voyager Mars 1971 mission are presented. Also described are: (1) the optimized candidate propulsion systems and their competing characteristics; (2) trade studies leading to the optimum candidate propulsion designs; and (3) an assessment of the preferred design. It is pointed out that in conducting the tradeoffs, velocity requirements and weight allocations presented in the Voyager 1971 preliminary mission description were used. Candidate propulsion designs for the 1971 mission were sized for a 3000-pound capsule, which slightly penalizes the performance of the solid/liquid designs. A solid/liquid system sized for a 3000-pound capsule can accommodate a 2000-pound capsule without redesign. Similarly, it was found that candidate solid/liquid designs for the 1975 and 1977 missions were sized for a 10,000-pound capsule. R.R.D.

N66-21118# Naval Research Lab., Washington, D. C.
SYNTHESIS OF NITROGEN FLUORIDES IN A NITROGEN PLASMA JET Final Report
B. R. Bronfin and R. N. Hazlett 12 Jan. 1966 16 p refs
(NRL-6340; AD-627787) CFSTI: HC $1.00/MF $0.50

Nitrogen-fluorine compounds have a high energy content, which makes them of interest in the propellant field. An electric arc technique, which has been used in the synthesis of other high-energy compounds, has now been applied to the nitrogen-fluorine system. A nitrogen plasma jet was intermixed with gaseous fluorides (CF_4SF_6) and subsequently quenched. Small yields of NF_3, N_2F_4, and CF_3NF_2 were produced, together with trace quantities of other products. The observed products were accounted for by a reaction sequence involving the formation of FCN and its subsequent stepwise fluorination by addition at the triple bond. FCN is only an intermediate, however, and had not been found in the product stream. The yield of fixed-nitrogen products is about 1% of inlet nitrogen for typical conditions, and it increases with increasing power input and increasing F/N ratio in the plasma. Author (TAB)

N66-21155# General Motors Corp., Indianapolis, Ind. Materials Labs.
METALLURGICAL FAILURE ANALYSIS OF Ti-6Al-4V ALLOY LEM PROPELLANT TANK, P/N 6848367, S/N P-009
U. L. Hellmann 19 Apr. 1965 19 p
(Rept.-65-FA8-6)

A Ti-6Al-4V alloy LEM propellant tank failed prematurely at 267 psig during hydrotest, approximately 74% of proof pressure. Failure initiated in the upper dome component and was due to an embrittled massive alpha structure that was encapsulated in the forging. This investigation was conducted to determine the nature and cause of failure and certain mechanical properties of the subject propellant tank. Author

N66-21477# Columbia Univ., New York. Dept. of Civil Engineering and Engineering Mechanics.
DEFORMATION AND FAILURE ANALYSIS OF REINFORCED GRAIN
A. M. Freudenthal Jun. 1965 60 p refs Presented at the Intern. Conf. on the Mech. and Chem. of Solid Propellants (4th Symp. on Naval Structural Mech.), Purdue Univ., Lafayette, Ind., 19–21 Apr. 1965
(Contract Nonr-266(78))
(TR-28; AD-627641) CFSTI: HC $3.00/MF $0.75

After considering the limitations imposed by the characteristic response of filled elastomers on the performance of case-bonded solid propellant grains, particularly the effect of loss of filler-binder interaction with increasing strain, the significant features of metal-wire of mesh-reinforced grains are discussed. The difference between the design criteria for such grains and for other types of reinforced structures is emphasized and the inapplicability of classical methods of visco-elastic analysis is discussed. Methods of analysis of elastic orthotropic, inhomogeneous, case bonded grains are summarized and their limitations show with respect to optimal utilization of the reinforcement. Such utilization requires thickness of the grain and the consideration of its elastic-plastic response in grain analysis. Author (TAB)

N66-21515# Rocketdyne, Canoga Park, Calif.
COMBUSTION STABILITY RATING TECHNIQUES Quarterly Progress Report, Period Ending 30 Dec. 1965
L. P. Combs, J. A. Murphy, E. E. Lockwood, F. W. Hoehn, and M. Alexander Jan. 1966 79 p refs
(Contract AF 04(611)-10811)
(R-6355-2; AD-627343) CFSTI: HC $3.00/MF $0.75

Work conducted on a study of liquid-propellant rocket combustion stability rating techniques is reported. Experimental tests were made for cold-flow characterization; of three rating methods: non-directional explosive bombs, directed blasts from explosive pulse guns, and directed flows of gases. Data relating the output characteristics of the method to particular design and input parameters are presented. Cold-flow characteristics are to be correlated with stability response of a rocket combustor when the techniques are applied during hot firings. Motor hardware and test stand preparations for the hot-firing program are described. Author (TAB)

N66-21695*# Bendix Corp., Southfield, Mich.
RESEARCH STUDY OF THE VORTEX VALVE FOR MEDIUM-TEMPERATURE SOLID PROPELLANTS
W. D. Holt and J. G. Rivard Washington, NASA, Apr. 1966 81 p refs
(Contract NAS1-4158)
(NASA-CR-424) CFSTI: HC $1.20/MF $0.75 CSCL 21I

The feasibility of throttling the flow of high temperature, contaminated gases with a vortex valve was studied on a 2000°F solid propellant gas generator, with a flow rate of 1 lb/sec. Six hot-gas secondary injection firings with this system, incorporating two vortex valves, supplied a flow of 1.0 lb/sec for 30 seconds. One of the vortex valves used active control, the other acted as pressure regulator maintaining the constant supply pressure by bypassing flow when the power valve was throttled. A flow modulation capability in excess of 4 to 1 was demonstrated. Cold gas testing of one-sixth scale model vortex valve resulted in changes of vortex valve geometry for optimal configuration and performance. Active control on both vortex valves and operation in a push-pull mode gave an amplitude attenuation of −4 db and a 28 degree phase lag at 30 cps. G.G.

N66-21728*# Harris Research Labs., Inc., Washington, D. C.
THE EFFECT OF SURFACE CONTAMINATION ON CONTACT ANGLES AND SURFACE POTENTIALS Summary Report
Anthony M. Schwartz and Alfred H. Ellison 13 Jan. 1966 46 p refs
(Contract NAS3-7104)
(NASA-CR-54708) CFSTI: HC $2.00/MF $0.50 CSCL 13H

A study was conducted to determine the effect on contact angles and surface potentials of contaminants applied to clean metal substrates and to determine the effectiveness of currently used propellant tank cleaning procedures in restoring the contact angles and surface potentials to the values obtained on the clean substrates. In addition, contact angle data were obtained for mercury on six different substrates over a range of temperatures from 25° to 150° C. Author

N66-21756# Astrosystems International, Inc., Fairfield, N. J.
AIR FORCE OFFICE OF SCIENTIFIC RESEARCH SIXTH ANNUAL CONTRACTOR'S MEETING ON CHEMICAL KINETICS OF PROPULSION
[1965] 46 p refs Meeting held in Pittsburgh, 20-21 Sep. 1965
(Contract AF 49(638)-1400)
(AFOSR-65-2238; AD-627978) CFSTI: HC $2.00/MF $0.50

The conference agenda and abstracts of the various papers are presented. Subject matter covered includes ion-molecule reactions in flames; concept of a mean temperature in flame reaction zone; energy distribution in the products of reactions in flames and electrical discharge; plasma jet chemistry; thermal reaction inhibition between hydrogen and oxygen; metallic beryllium combustion; kinetics of fluorine compound reactions; cyclopropane derivatives containing fluorine; hydrogen–fluorine reaction; combustion kinetics of tetrafluorethylene; chemical synthesis with ion beams; chemical reactions on clean surfaces with modulated atomic beam techniques; physics of metastable systems; helium ion interaction with metallic surfaces; combustion gas emitted radiation and chemiluminescence phenomena; high temperature chemical kinetics; decomposition kinetics of ammonium perchlorate; sticking probability of hydrocarbons on tungsten; kinetic and aerodynamic aspects of the attack of refractory materials by dissociated gases; interfacial rate processes in flow systems; kinetics of hydrogen–oxygen and hydrocarbon–oxygen reactions; and chemical reactions in a monothermal field. M.G.J.

N66-21808*# California Univ., Davis.
INFRARED RADIATION MEASUREMENTS OF COMBUSTION GASES Sixth Quarterly Progress Report, 1 Oct.–31 Dec. 1965
W. H. Giedt [1966] 16 p
(Contract NAS8-11468)
(NASA-CR-71526) CFSTI: HC $1.00/MF $0.50 CSCL 20M

Modifications in mounting arrangements and a window holder used to define the test path length are reported for an experimental apparatus designed to obtain the spectral characteristics of a number of common combustion products. The key element in this apparatus is a graphite resistance furnace with an inert ceramic tube liner for the containment of high temperature gases. A beam of radiation from a high temperature source is directed through a known length of test gas in the center region of the furnace. A monochrometer on the opposite end of the furnace is then used to measure the amount of energy absorbed as a function of wavelength. C.T.C.

N66-21862# Library of Congress, Washington, D. C. Aerospace Technology Div.
FOREIGN SCIENCE BULLETIN, VOLUME 2, NUMBER 3
Mar. 1966 80 p refs

Presented is a compilation of selected foreign scientific and technical literature sponsored by the Department of Defense. Some of the topics considered are: the method of potential functions, two-photon optically pumped semiconductor lasers, the controlling zone in the combustion of composite propellants, new trends in the development of aromatic polyesters in the USSR, loss in antenna gain in long-haul UHF tropospheric propagation, microwave techniques for lasers, solid fuels for ramjet engines, high-temperature properties of liquid alkali metals, and effect of fillers on the morphological forms and mechanical properties of crystaline polymers. Reports are included on the following conferences: the spectral transparency of the atmosphere in the visible and infrared regions of the spectrum, and problems in material science. Reviews are presented for the following books: *Molecular Scattering of Light*, and *Methods of Studying the Most Recent and Contemporary Tectonics of the Shelf Zones of Seas and Oceans*. A brief biography on Lev Davidovich Landau is also included. M.R.W.

N66-22197*# Stanford Research Inst., Menlo Park, Calif.
PROPELLANT COMBUSTION PHENOMENON DURING RAPID DEPRESSURIZATION Quarterly Report No. 1, Jul. 1–Sep. 30, 1965
E. L. Capener, Lionel A. Dickinson and Gerald A. Marxman 12 Oct. 1965 36 p refs
(Contract NAS7-389)
(NASA-CR-71758) CFSTI: HC $2.00/MF $0.50 CSCL 21I

Studies were conducted to develop an understanding of the processes occurring during rapid depressurization of burning solid propellants. A theoretical model was proposed which appeared capable of explaining a large volume of combustion instability data. Burning rates of propellants with various oxidizers and binders were studied and data obtained are given. Lower deflagration and ignition threshold pressures for propellants of the same general composition were observed. The analytical studies are discussed and it is reported that a simple linear or exponential pressure-dependent type of burning law cannot adequately explain non-steady state phenomena. H.S.W.

N66-22276*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
A METHOD OF APPROXIMATING PROPELLANT REQUIREMENTS OF LOW-THRUST TRAJECTORIES

Charles L. Zola Washington, NASA, Apr. 1966 53 p refs
(NASA-TN-D-3400) CFSTI: HC $0.80/MF $0.50 CSCL 22C

An approximation method for calculation of optimum trajectory solutions for low-acceleration flight in an inverse-square gravitational field is presented. This method is based on the dynamic similarity between flight on an optimum trajectory in the inverse-square field and rest-to-rest flight on a rectilinear path in gravity-free space. Consequently, the equivalent rectilinear path length L becomes a measure of the propulsive effort of trajectories similar to the characteristic velocity increment ΔV. Examples of the use and validity of the method are given for different types of interplanetary trajectory problems. When applied to typical circular orbit transfer problems, the approximation method can predict ΔV with an error of 10 percent or less. It is shown that errors in the method are most serious for flyby trajectories, becoming as large as 40 percent in terms of ΔV. However, typical specific impulse values for low-acceleration flight reduce the ΔV error by a factor of two or more when translated into error in propellant consumption. The possibility of improving accuracy is discussed, and it is shown that a more general (and more complicated) type of rectilinear flight with nonzero velocities at the terminals may be required.
Author

N66-22321*# Jet Propulsion Lab., Calif. Inst. of Tech., Pasadena.
ALPS GENERANT TANK AND CELL ASSEMBLY
O. F. Keller and L. R. Toth 28 Feb. 1966 53 p refs
(Contract NAS7-100)
(NASA-CR-71794; JPL-TR-32-865) CFSTI: HC $3.00/MF $0.50 CSCL 22B

The relative advantages of diaphragm-type bladders and balloon-type bladders for expulsion of hydrazine to an advanced liquid propulsion system were investigated. Bladder materials were butyl and ethylene propylene elastomers. Ribs were used to increase expulsion efficiencies at higher pressures. Water expulsion tests were made at pressures up to 100 psig to simulate the flight type generant tank. Two heavy weight steel generant tanks were fabricated for testing as part of a Mariner 1966 prototype subsystem. Expulsion pressures were generally limited to 1300 psig. Three flight type titanium generant tanks were fabricated for testing in a pressurization subsystem. A detailed description of the titanium generant tank fabrication procedure is included.
Author

N66-22342* National Aeronautics and Space Administration Marshall Space Flight Center, Huntsville, Ala.
OPTIMIZATION OF SLOSH BAFFLE GEOMETRY
H. Buchanan *In its* Aero-Astrodyn. Res. Rev. No. 3 15 Oct. 1965 p 95–100 refs (See N66-22329 11-34) CFSTI: HC $4.00/MF $1.00

This paper describes a method for determining the optimum baffle configuration for suppressing excessive propellant sloshing in the tanks of a large launch vehicle. The optimum geometry for a baffle system is considered to be the one with the least mass which is capable of providing the necessary damping. The analysis considers a cylindrical tank and a baffle system made up of several flat ring baffles mounted horizontally. The basic assumptions are discussed and derivations given of the equations necessary to predict the optimum baffle configuration consistent with adequate strength. Numerical results are presented graphically, and some general conclusions are drawn.
Author

N66-22354*# Northrop Space Labs., Hawthorne, Calif.
FOLLOW-ON STUDIES AND INVESTIGATION RELATED TO THE CHEMICAL HAZARDS POTENTIAL STUDY Final Report
M. S. Christensen Mar. 1966 269 p refs
(Contract NAS9-4795)
(NASA-CR-65321; NSL-65-136-1) CFSTI: HC $6.00/MF $1.50 CSCL 14B

This study has explored the hazards entailed in the proposed operation of a space chamber containing spacecraft with loads of cryogenic hydrogen and oxygen on board. Hazards ensuing from leakage, partial spill, or total rupture of tankage were assessed. Mathematical analyses were performed, to compute the effects upon the structure of explosive reactions from released gases under several chamber pressures. An experimental program was run concurrently, to support the analysis. Suggested modifications for the chamber are offered (including costs and schedules for accomplishment), to improve its structural resistance to computed dynamic effects. Recommendations are furnished for fire hazard detection/suppression systems; and recommended operating procedures, to improve safety of operation, are presented.
Author

N66-22485# Aerospace Medical Div. Aerospace Medical Research Labs. (6570th), Wright-Patterson AFB, Ohio.
THE EFFECT OF INJECTED MONOMETHYLHYDRAZINE ON PRIMATE PERFORMANCE Final Report, 26–29 Oct. 1964
Kenneth C. Back, Herbert H. Reynolds, and Henry W. Brunson Sep. 1965 25 p refs Prepared jointly with Aeromed. Res. Lab.
(AMRL-TR-65-82; AD-628048) CFSTI: HC $1.00/MF $0.50

Nine macaque monkeys were injected on two occasions with either 2.5 or 5.0 mg/kg of monomethylhydrazine (MMH). Operant task performance was measured, and clinical symptoms were noted. No difference in performance resulted from the two dosage levels, but there was a greater incidence of clinical symptoms in those subjects exposed to 5.0 mg/kg. In over half the cases a performance decrement preceded clinical symptoms, but in no instance did clinical symptoms precede a performance decrement. In 3/18 cases clinical symptoms did appear without a performance decrement, but in 4/18 cases a performance decrement occurred in the absence of clinical symptoms. When initial 2.5 or 5.0 mg/kg injections are made one might predict that performance decrements will occur between 1 and 2 hours and clinical symptoms between 2 and 2.5 hours in about half the subjects. A second exposure might be expected to produce performance decrements between 1 and 2 hours and clinical symptoms between 2 and 3 hours in the majority of subjects. If a subject is influenced by MMH, clinical symptoms will likely disappear between 3 and 9 hours following injection, and performance should return to baseline level between 3 and 30 hours.
Author

N66-22489# Purdue Univ., Lafayette, Ind. Dept. of Chemistry.
RESEARCH IN NITROMONOMERS AND THEIR APPLICATION TO SOLID SMOKELESS PROPELLANTS Annual Progress Report No. 27, 15 Sep. 1964–14 Sep. 1965
Henry Feuer 30 Nov. 1965 44 p refs
(Contract Nonr-1100(13))
(AD-624300) CFSTI: HC $2.00/MF $0.50

The reactions of diborane with aliphatic aldoximes and ketoximes lead to intermediates which on basic or acidic hydrolysis afford exclusively the corresponding N-monosubstituted hydroxylamines in yields of 50–90%. The intermediates from the reaction of diborane with alpha-aryl aldoximes and ketoximes give only on acid hydrolysis the desired hydroxylamines. Primary and secondary nitroalkanes which are unaffected by diborane interact readily in the form of their salts with this reagent. The reaction leads to intermediates which on basic or acid hydrolysis afford N-monosubstituted hydroxylamines in yields of 30–60%. The scope of the alkyl nitrate nitration was successfully extended to heterocyclic systems such as piperidones and pyrrolidones. TAB

N66-23041# Institut Franco-Allemand de Recherches, St. Louis (France).
MEASUREMENT OF THE AIR BLAST PRODUCED BY THE EXPLOSION OF CONFINED PROPULSIVES, PART 3 [LUFTSTOSSMESSUNGEN AN EXPLODIERENDEN VERDAMMTEN RAKETENTREIBSTOFFEN, 3. TIEL]
M. Frobose 2 Nov. 1964 33 p refs In GERMAN
(ISL-T-3T/64) CFSTI: HC $2.00/MF $0.50

Cylindrical two-compartment containers filled with nitrogen tetroxide and nonsymmetrical dimethylhydrazin (UDMH), respectively, were used to simulate rocket explosions on launching pads. Detonations were initiated through mixing of the two fuel components; distributions of the resulting shock waves and their pressure time histories were obtained by piezoelectric sensors installed at various distances from the explosion point. All obtained pressure oscillograms showed a general similar pattern. Extrapolated time-pressure curves of the direct shock wave up to the assumed zero point differed with the collected distance-pressure values. These discrepancies were attributed to a possible uneven mixing of the hypergolic propellant, and construction or material weaknesses of the fuel tanks used. Transl. by G.G.

N66-23086# Princeton Univ., N. J. Dept. of Aerospace and Mechanical Sciences.
COMBUSTION PROCESSES IN LIQUID PROPELLANT ROCKET MOTORS Final Report, 1 Sep. 1962–31 Aug. 1963
Irvin Glassman 22 Dec. 1965 12 p refs
(Grant AF-AFOSR-111-63)
(AFOSR-65-2933; AD-627712) CFSTI: HC $1.00/MF $0.50

Princeton University has been engaged in a long range program on combustion processes in liquid propellant rocket motors. Aspects of this program are still continuing. During the period of 1 September 1962 to August 63, the work was supported by Air Force Office of Scientific Research Grant 111-63. The detailed technical accomplishments have been published in the open literature as listed in the section on publications. The report reviews the history, results, and publications of the research program up to 31 August. TAB

N66-23183# California Inst. of Tech., Pasadena. Firestone Flight Sciences Lab.
SOLID ROCKET STRUCTURAL INTEGRITY ABSTRACTS, VOLUME II, NO. 4
R. A. Westmann, ed. Oct. 1965 154 p refs
(Contract AF 04(611)-9572)
(AD-475623)

CONTENTS:

N66-23184 Rocketdyne, McGregor, Tex.
CHARACTERIZATION OF SOLID PROPELLANTS AS STRUCTURAL MATERIALS
S. C. Britton *In* Calif. Inst. of Tech. Solid Rocket Structural Integrity Abstr., Vol. 2, No. 4 Oct. 1965 p 1–71 refs (See N66-23183 12-27)

The present state-of-the-art in laboratory methods for the characterization of solid propellants as structural materials is discussed with emphasis on related work on rubber and other polymers. Grain structural design analyses contained: (1) A complete definition of the stress and strain states throughout the propellant grain for a given loading condition; (2) suitable failure criteria as developed from strength analyses and required safety margins; and (3) results of scale model and analogue motor tests, and of full motor tests where feasible. A summary of most of the uniaxial and multiaxial laboratory tests for experimental characterization of propellant failure behavior is presented that include mechanical, thermal, optical, physico-chemical, as well as special test procedures and theoretical considerations. G.G.

N66-23205# Atlantic Research Corp., Alexandria, Va. Kinetics and Combustion Group.
RESEARCH ON THE DEFLAGRATION OF HIGH-ENERGY SOLID OXIDIZERS Final Technical Report, 1 Jun. 1962–30 Nov. 1965
J. B. Levy, G. von Elbe et al 30 Nov. 1965 60 p refs
(Contract AF 49(638)-1169)
(AFOSR-66-0157; AD-628035) CFSTI: HC $3.00/MF $0.75

The results of research on the deflagration of the solid-propellant oxidizers, hydrazine perchlorate (HP) and hydrazine diperchlorate (HDP), are reported and discussed. Each compound was found to be unique physically and chemically, in both its low-temperature thermal decomposition and its high-temperature deflagration behavior. HP and HDP are white solids of crystal densities 1.939 and 2.21 g/cc, and melting points of 141 and 191C, respectively. The following aspects of the combustion process were studied: The deflagration rate as a function of pressure and the effects of catalysts; the flame temperature and the temperature profile through the combustion, and chemical behavior. In addition, vaporization rates of HP were measured. Author (TAB)

N66-23466*# Northrop Space Labs., Huntsville, Ala.
SLOSH DESIGN HANDBOOK I
James R. Roberts, Eduardo R. Basurto, and Pei-Ying Chen Washington, NASA, May 1966 328 p refs
(Contract NAS8-11111)
(NASA-CR-406) CFSTI: HC $3.25/MF $1.75 CSCL 21I

Design information related to the effects of propellant sloshing is presented for use in both control and structural problems. Both analytical and experimental results are given and all pertinent material is referenced. Graphs have been included, whenever possible, to expedite preliminary design calculations. The areas covered are: (1) linearized fluid theory, (2) equivalent mechanical model theory, (3) results of analytical studies of liquid oscillations in variously shaped containers when subjected to different types of excitation, i.e., boundary conditions, fluid velocity potential, natural frequencies, liquid force and moment resultants and equivalent mechanical models, and (4) results of both analytical and experimental studies concerned with propellant slosh suppression, with particular emphasis on fixed-ring baffles. Author

N66-23563*# Aerojet-General Corp., Sacramento, Calif. Liquid Rocket Operations.
ANALYSIS AND EXPERIMENTAL VERIFICATION OF AXIAL THRUST ON THE M-1 LIQUID OXYGEN TURBOPUMP
J. J. Brunner 15 Apr. 1966 99 p ref
(Contract NAS3-2555)
(NASA-CR-54817; AGC-8800-51) CFSTI: HC $3.00/MF $0.75 CSCL 21H

Axial thrust characteristics of two oxidizer turbopump assemblies are presented and evaluated over a representative range of speed, flow, and suction pressure. Estimates of thrust changes resulting from impeller backvane modifications and thrust verification tests conducted with a three-eighths size subscale pump are discussed. All tests were conducted with liquid nitrogen as the pumping fluid and either gaseous nitrogen or gas generator turbine drive. The turbopump consists of a centrifugal pump directly driven by a single-stage impulse turbine. The shaft is supported in rolling contact, propellant cooled bearings. The 27,000 shp turbopump has a nominal heat generating capability of 3400 ft. The 28.5-in. urshrouded impeller produced a maximum thrust of approximately 70,000 lb towards suction. Net thrust was measured using calibrated sleeve-mounted strain gages. Author

N66-23798*# Lockheed Missiles and Space Co., Sunnyvale, Calif.
RF LIQUID-LEVEL SENSING TECHNIQUE
James D. Lockhart 28 Feb. 1966 151 p refs
(Contract NAS8-11476)
(NASA-CR-74204; LMSC-A785006) CFSTI: HC $5.00/MF $1.00 CSCL 14B

The development of an rf liquid-level sensing technique is presented. The feasibility of a resonant cavity technique was determined through a series of tests, and refined design information was obtained for evaluating the technique. The basic principle is that the dielectric property of a fluid contained in a tank (cavity) with conducting walls causes the resonant frequency to change in proportion to the amount of fluid in the cavity. The cavity is excited by rf electrical energy, and a change is detected in the resonant frequency when it is compared to that of the empty tank. By applying a scaling factor, the level or volume of the fluid in the tank is determined. C.T.C.

N66-23849* National Aeronautics and Space Administration, Washington, D. C.
HIGH ENERGY PROPELLANTS—A CONTINUING BIBLIOGRAPHY, WITH INDEXES
Apr. 1966 98 p
(NASA-SP-7002(02)) CFSTI: HC $1.00/MF $0.50 CSCL 21I

A selection of annotated references to unclassified reports and journal articles relating to high energy propellants that were introduced into the NASA information system during the period January through December 1965, are presented. The references are part of a continuing bibliography, and are concerned with research and development studies on solid, liquid, and hybrid propellants and oxidizers. The bibliography also covers related topics such as propellant handling and storage, combustion characteristics, toxicity, and hazards and safety measures. A subject index and personal author index are included. L.S.

N66-23851*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
SIMULATOR FOR STATIC LIQUID CONFIGURATION IN PROPELLANT TANKS SUBJECT TO REDUCED GRAVITY
William A. Olsen Washington, NASA, May 1966 42 p refs
(NASA-TN-D-3249) CFSTI: HC $2.00/MF $0.50 CSCL 14B

A device that can simulate the isothermal equilibrium static liquid configuration in two-dimensional propellant tanks of various shapes and sizes that are subject to reduced gravity ranging from 1 to near zero gravity, was constructed; and the design and operating criteria of the device are discussed. Experimental results involving flow past flat plates indicate that the two-dimensional simulator can show the approximate equilibrium liquid shape in many surface-of-revolution containers over a range of tank size and gravity field when scaled by the Bond number; and when the proper procedure is used in its operation, and interpretation of data. The experiments also indicate that the device can simulate three-dimensional tanks approximately. L.S.

N66-23978# Princeton Univ., N. J. Dept. of Aerospace and Mechanical Sciences.
RESEARCH ON SOLID PROPELLANT COMBUSTION INSTABILITY Final Summary Report, 1 Jan.–30 Sep. 1964
R. H. Woodward Waesche and Martin Summerfield Feb. 1966 31 p refs *Its* Aeron. Eng. Rept.-766
(Grant AF-AFOSR-448-63; ARPA Order 317-62)
(AFOSR-66-0578; AD-629585) CFSTI: HC $3.60/MF $0.50

A search was made for predicted temperature waves using a 2-inch diameter T-burner as the source of oscillating pressure, in order to confirm the observations of Wood (9th Symposium on Combustion, p. 335, 1963); and then to measure the pertinent parameters, namely temperature, amplitude and phase. Unfortunately, no waves of the predicted type were found. However, waves similar to those of Wood were observed reproducibly when burning was allowed on the sides of an uninhibited test sample, i.e., in a non-one-dimensional situation, but even so these waves were much weaker than the temperature variations that were expected. Various reasons for the non-occurrence of the expected temperature waves are considered. The most likely explanation is that the model of the gas phase reaction zone originally assumed, namely, a thin one-stage reaction zone is partially in error. Instead, it appears that the gaseous zone may be composed of two portions a thin primary zone near the surface needed in order to account for the observed burning rates, and a diffuse afterburning zone where the combustion reactions go to completion. Such a spread in the reaction zone would imply a longer total reaction. TAB

N66-24347# Ballistic Research Labs., Aberdeen Proving Ground, Md.
EXPERIMENTAL MEASUREMENTS OF ACOUSTIC EROSIVITY EFFECTS ON PROPELLANT BURNING RATES
Richard C. Strittmater, William P. Aungst, Clifton E. Thompson, and Lelland A. Watermeier *In* APL Proc. of the 4th Meeting, Tech. Panel on Solid Propellant Combustion Instability Apr. 1964 p 9–15 refs Presented at the AIAA Solid Propellant Rocket Conf., Palo Alto, Calif., Jan. 1964 (See N66-24346 13-33) CFSTI: HC $4.00/MF $0.75

Acoustic erosivity effects were experimentally measured for double base propellant, ARP, samples. A modification of the resonant tube technique developed for acoustic admittance studies was used. The test chamber, schematically illustrated, is in the form of a T-burner. Product gases were exhausted into a duct tank through a single exhaust port. The propellant was burned at both ends to attain higher acoustic amplitudes. Oscillatory pressures of 160 psi peak to peak amplitudes were obtained at a mean pressure of 300 psi. It was shown that with very high amplitude oscillations there could be the combined effect of DC erosion plus the resonant phenomena being measured. A portion of the pressure records taken at three positions in the combustion tube during the simultaneous burning of the erosion samples and drivers are shown, and are discussed. Curves plotted from data from two separate runs showing the position of the burning propellant surface as functions of both time and acoustic pressure amplitude, are given. L.S.

N66-24348# Princeton Univ., N. J.
PROBLEMS IN LIQUID PROPELLANT INSTABILITY
David T. Harrje *In* APL Proc. of the 4th Meeting, Tech. Panel on Solid Propellant Combustion Instability Apr. 1964 p 19–23 refs (See N66-24346 13-33) CFSTI: $4.00/MF $0.75
(Grant NsG-99-60)

A series of experiments using a variable-length rocket motor were conducted for determining problems of combustion instability in liquid propellant rocket engines. A pressure-sensitive time lag approach was used. By varying both length and mixture ratio, zones of first, second, and third longitudinal mode were found. Parameters studied included velocity effects, fan orientation, radial orifice alignment, chamber pressure, and interfan spacing. Mass and mixture ratio surveys across the injector face were used to indicate the overall effect of any one of the injector patterns. L.S.

N66-24349# Dartmouth Coll., Hanover, N. H. Thayer School of Engineering.
AN EXPERIMENTAL STUDY OF SOLID PROPELLANT COMBUSTION INSTABILITY IN A STANDING WAVE TUBE
A. O. Converse *In* APL Proc. of the 4th Meeting, Tech. Panel on Solid Propellant Combustion Instability Apr. 1964 p 25–29 (See N66-24346 13-33) CFSTI: HC $4.00/MF $0.75

Experiments were conducted in a standing wave steel pipe tube for developing methods of measuring the acoustic admittance of a burning propellant surface. Solid propellant samples bonded to the face of a piston were ignited by a heat nichrome wire after the piston was in motion already (the piston was driven by a variable speed electric motor through a scotch yoke). The amplitude and frequency of the pressure disturbance caused by the piston motion was under control of the investigator. Pressure was sensed by a water cooled Kistler quartz transducer located in the wall of the pipe, a few inches from the piston. The electrical signal from the transducing element was recorded with a pen writing oscillograph. Typical experimental conditions are given, and typical experimental results are both tabulated and discussed. The experiments demonstrated instability at low frequency and pressure. It is hoped that the method will yield values of the admittance. It has already indicated a nonlinear excitation mechanism. L.S.

N66-24356# Canadian Armament Research and Development Establishment, Valcartier (Quebec).
THE INFLUENCE OF AXIAL COMBUSTION INSTABILITY ON THE DEVELOPMENT OF A 23KS20000 MOTOR
F. Jackson, W. G. Brownlee, and A. K. Roberts *In* APL Proc. of the 4th Meeting, Tech. Panel on Solid Propellant Combustion Instability Apr. 1964 p 77–82 refs (See N66-24346 13-33) CFSTI: HC $4.00/MF $0.75

The finite wave axial combustion instability of aluminized ammonium perchlorate/polyurethane (Cardeplex) propellants were ballistically tested with a 17-inch diameter, 180-inch long 23KS20000 solid propellant rocket motor. Summaries of the findings regarding (1) oscillation mode, (2) initiation, (3) burning rate changes, (4) influence of chamber pressure, initial grain temperature, binder level, aluminum level, aluminum type and size, burning rate modifiers, scalers, and motor length, and (5) gross trend for compositional changes are given. These findings were compared with observed trends reported in a double-ended burner. A table of propellant data for various formulations (obtained by addition of 1.8% lithium fluoride) used for other test firings with the motor is presented. L.S.

N66-24357# Hercules Powder Co., Cumberland, Md. Allegany Ballistics Lab.
LOW FREQUENCY ACOUSTIC INSTABILITY STUDIES WITH DOUBLE BASE PROPELLANTS
S. F. Mathews *In* APL Proc. of the 4th Meeting, Tech. Panel on Solid Propellant Combustion Instability Apr. 1964 p 84–86 (See N66-24346 13-33) CFSTI: HC $4.00/MF $0.75
(Contract NOrd-16640)

Test firings of a non-aluminized composite modified double base propellant (DCK) in a EM-60 solid propellant rocket motor were conducted at constant frequency to determine reproducibility and the effects of equilibrium chamber pressure on the growth and decay rates of the oscillation. The signals were band pass filtered between 200 cps and 500 cps to obtain only the fundamental mode. The reduced data from these firings are presented in a table. Also shown are values for the average chamber pressure over the period where growth and decay rates were measured. The sum of the growth and decay rates were fairly reproducible, and this parameter was used to evaluate the effect of pressure on the propellant acoustic response. These data are also given, and they indicate that the propellant response at the frequency is increased at very low pressure. Based on the best data available, the experimental values yielded a response function of about 0.6 for the double base propellant at 360 cps and at an average pressure of 350 psi. L.S.

N66-24358# Stanford Research Inst., Menlo Park, Calif.
BULK COMPRESSIBILITY OF SOLID PROPELLANTS
Thor L. Smith and James R. Smith *In* APL Proc. of the 4th Meeting, Tech. Panel on Solid Propellant Combustion Instability Apr. 1964 p 87–90 refs (See N66-24346 13-33) CFSTI: HC $4.00/MF $0.75
(Contract NOw-61-1037-d)

Bulk compressibility data curves for several polyurethane propellant compositions containing either 70% or 80% solids, and for a binder are depicted. The data on the propellants were analyzed in terms of $B_T = B_i V_i$ where B_i and V_i are the compressibility and volume fraction, respectively of the i^{th} component. From the determined compressibilities of the propellants, assumed values for ammonium perchlorate and aluminum, and the volume fractions of the binder, ammonium perchlorate, and aluminum, the compressibility of the binder B_i was computed. The experimental data for the binder in both propellants are in excellent agreement with theoretical calculations. L.S.

N66-24720# Thiokol Chemical Corp., Denville, N. J. Reaction Motors Div.
AFOSR COMBINED CONTRACTORS MEETING ON COMBUSTION DYNAMICS RESEARCH Compilation of Abstracts

[1965] 77 p Meeting Held 1-4 Jun. 1965
(Contract AF 49(638)-1505)
(AFOSR-65-0590; AD-623186) CFSTI: HC $3.00/MF $0.75

A series of abstracts are presented on the combustion dynamics of liquid and solid propellant rocket engines. Topics include combustion instability mechanisms and studies of combustion instability under various conditions for liquid and gaseous propellant engines; supersonic combustion problems, waves and oscillations; injector design; jet mixing; thermal and light emission; and propulsion chemistry. Solid propellant research includes ignition and burning, combustion characteristics and combustion instability, and burning rate measurements. E.A.O.

N66-24733# Harry Diamond Labs., Washington, D. C.
LOW-LOSS STYRENE-TYPE FOAM-IN-PLACE ENCAPSULATING RESINS
F. J. O. Engelhardt 15 Oct. 1965 24 p refs
(HDL-TR-1308; AD-628537) CFSTI: HC $2.60/MF $0.50

Low-dielectric-loss styrene-type foam-in-place encapsulating resins are not available commercially. Such a resin has now been developed. A propellant was added to the catalyzed styrene-polystyrene mixture; as the temperature of the polymerizing resin rose, the propellant expanded the resin into a cellular structure. Homogeneous foams were obtained in the presence of finely powdered polymers, which acted as bubble nucleators. The resultant rigid foams had dielectric constants ranging from 1.2 to 1.8, and loss tangents from 0.0002 to 0.001 over the frequency range 10^2 and 10^8 cps. Some of these materials had remarkably flat loss-frequency curves, losses ranging only between 0.0004 and 0.0005 over the same frequency range. Densities were varied between 0.194 and 0.850 g/cm^3, or between 12 and 53 lb/ft^3. These data indicate the usefulness of the new cellular materials as rf encapsulating resins. Author (TAB)

N66-24762# Library of Congress, Washington, D. C. Aerospace Technology Div.
COMBUSTION INSTABILITY IN LIQUID AND SOLID PROPELLANT ROCKETS Surveys of Soviet Scientific and Technical Literature
Paul Vantoch 22 Nov. 1965 60 p refs Compilation of abstracts
(ATD-65-106)

This comprehensive report is based on Soviet open sources published 1960–1965 (with a few sources from earlier dates); it is the first in a series dealing with combustion instability in liquid- and solid-propellant rockets. Several theoretically derived criteria for combustion instability are discussed and their limitations for predicting performance characteristics are pointed out. The effect of various factors such as pressure, temperature gradient, temperature sensitivity, and particle size on the burning velocity are reviewed and their significance for instability is outlined. Other potential elements of combustion instability such as the phase transformations and physical-reaction mechanisms are also treated. Articles on high- and low-frequency instability, theoretical derivation of stability criteria, and experimental investigations of instability are reviewed. Factors influencing instability are summarized and discussed together with suggested measures for suppressing instability. Author

N66-24815# Atlantic Research Corp., Alexandria, Va.
A STUDY OF THE HYDROGEN–FLUORINE REACTION Final Report, 1 Feb. 1962–1 Feb. 1966
Joseph B. Levy Feb. 1966 5 p refs
(Contract AF-49(638)-1131)
(AFOSR-66-0410; AD-628923) CFSTI: HC $1.10/MF $0.50

The research program consisted of the study of the reactions of fluorine and fluorine-like species with hydrogen and other fuel-type molecules. The main effort was directed at the study of the gaseous hydrogen–fluorine system. The thermally-initiated reaction, including the effects of species that inhibit and promote the reaction were investigated. The area of interest also includes the study of fluorine with other species, such as hydrocarbons and the study of the reactions of fluorine-like compounds such as oxygen difluoride and tetrafluorohydrazine. The general approach is to study the kinetics of the reactions of these species in order to gain an understanding of the mechanisms of the reactions and of the ways in which species that inhibit or accelerate these reactions exert their effects. Author (TAB)

N66-24820# Monsanto Research Corp., Everett, Mass.
EFFECTS OF SELECTED STRAINS OF MICROORGANISMS ON THE COMPOSITION OF FUELS AND LUBRICANTS Final Report, 1 Sep. 1962–27 Nov. 1964
Glenn R. Wilson, John O. Smith, H. F. Martin, Dolph Klein, E. C. Harrington et al Wright-Patterson AFB, Ohio, Res. and Technol. Div., Jan. 1966 154 p refs
(Contract AF 33(657)-9814)
(RTO-TDR-63-4117, Pt. II; MRB-2023F, AD-628673)

A select number of aerobic bacterial and fungal cultures (isolates from contaminated fuel tank bottoms) were screened against a variety of jet fuels (JP-4 and JP-6), a lubricant, a liquid rocket propellant, and a spectrum of pure hydrocarbons (naphthenes and normal and branched alkanes) for growth-supporting properties. Variable growth support on all jet fuel samples was noted with the exception of one which was found to contain no detectable normal alkanes. Removal of normal alkanes from the other jet fuel samples significantly reduced their growth-supporting properties. The normal alkanes supported the most growth, the 2-methyl and 2,2-dimethyl alkanes lesser growth, and the naphthenes no growth support. After the prolonged incubation of several of the bacterial cultures on the initially resistant jet fuel sample, several cultures adapted to it. A variety of jet fuel additives were also screened against bacterial cultures and certain types were found to inhibit growth. Author (TAB)

N66-24930*# National Aeronautics and Space Administration, Lewis Research Center, Cleveland, Ohio.
INITIAL INVESTIGATION OF A METHOD WHEREBY A CRYOGENIC PROPELLANT LIQUID IS INSULATED FROM HEAT LEAK BY THE PROPELLANT AND ITS SACRIFICIAL BOILOFF
William A. Olsen Washington, NASA, May 1966 39 p refs
(NASA-TN-D-3228) CFSTI: HC $2.00/MF $0.50 CSCL 20M

A small-scale experiment is reported which demonstrated that a few closely spaced thin-film plastic "bags," hydraulically connected and mounted close to the propellant tank wall with liquid hydrogen in all volumes, could act as sufficient insulation to cause liquid in the volume nearest the tank wall to boil off sacrificially much of the incoming heat leak. Thus, much of this heat leak is prevented from reaching the liquid shielded by this insulator. As a consequence, the temperature of the liquid in a pressurized tank increases at a much slower rate than it would if there were no bags. In this case, the heat leak to the shielded liquid is essentially independent of the incoming heat leak to the tank and depends only on the tank pressure. The lowest heating rates are possible for low tank pressures. This method could result in a weight saving for booster rocket vehicles designed for its application because it can reduce the pump cavitation problem by decreasing the liquid heating rate. Further weight saving appears to be possible in pressurization system weight. The greatest overall weight saving occurs at low tank pressures. Author

N66-24946*# North American Aviation, Inc., Downey, Calif. Launch Vehicle Dynamics Group.
A STUDY OF LONGITUDINAL OSCILLATIONS OF PROPELLANT TANKS AND WAVE PROPAGATIONS IN FEED LINES. PART I: ONE-DIMENSIONAL WAVE PROPAGATION IN A FEED LINE
Henry Wing and Clement L. Tai 31 Mar. 1966 126 p refs
(Contract NAS8-11490)
(NASA-CR-74739; SID-66-46-1) CFSTI: HC $4.00/MF $1.00 CSCL 20D

In this report, the dynamics of elastic propellant feed lines with streaming fluid are analyzed using the nonlinear one-dimensional unsteady compressible fluid flow equations. The viscous effect of the fluid is assumed to be expressible in the form of a hydraulic resistance corresponding to turbulent flow. Transfer functions relating the pressures, velocities, and the corresponding phase angles were derived from the linearized equations for the perturbed state. The governing equations were also converted into a system of four first-order ordinary nonlinear differential equations by the method of characteristics. These were then transposed into finite difference form and solved numerically on a digital computer. Impulse, step, and sinusoidal velocity disturbances were considered in the numerical solution for a feed line with and without a control device. The physical parameters of the liquid hydrogen line on the Saturn S-II engine are used for the numerical calculations to illustrate the results. Author

N66-24947*# North American Aviation, Inc., Downey, Calif. Space and Information Systems Div.
A STUDY OF LONGITUDINAL OSCILLATIONS OF PROPELLANT TANKS AND WAVE PROPAGATIONS IN FEED LINES. PART II: WAVE PROPAGATION IN ELASTIC PIPE FILLED WITH INCOMPRESSIBLE VISCOUS FLUID
Michael M. H. Loh and Clement L. Tai 21 Jan. 1966 55 p refs
(Contract NAS8-11490)
(NASA-CR-74740; SID-66-46-2) CFSTI: HC $3.00/MF $0.50 CSCL 20D

An analysis was made of pressure waves being propagated through a system at rest, as part of a study of longitudinal wave propagation in an elastic pipe filled with an incompressible and viscous fluid. The influence of pipe wall inertia on wave propagation and its correlation with fluid viscosity was studied. The mathematical model was formulated by deriving a characteristic equation from elastic equilibrium of the pipe and Navier–Stokes fluid flow. Two sets of phase velocities and attenuation factors were obtained from the reduced characteristic equation for various viscosity and inertia parameters. The phase velocities and attenuation factors were obtained as longitudinal and radial inertia parameters representing pipe wall inertia and a viscosity parameter. The relations are delineated in the form of graphs. E.A.O.

N66-25002*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
PERFORMANCE OF ROCKET NOZZLE MATERIALS WITH SEVERAL SOLID PROPELLANTS
James R. Johnston, Robert A. Signorelli, and John C. Freche Washington, NASA, May 1966 36 p refs
(NASA-TN-D-3428) CFSTI: HC $1.00/MF $0.50 CSCL 21H

Rocket nozzle throat insert materials were investigated by using three small-scale solid-propellant rocket engines. The materials used included refractory metals, refractory-metal carbides, graphites, ceramics, cermets, and fiber-reinforced plastics. Three propellants with widely differing flame temperatures and oxidation characteristics were used. The flame temperatures were 4700°, 5600°, and 6400° F. The engines were designed to provide a chamber pressure of 1000 pounds per square inch and a firing duration of 30 seconds with a nozzle throat diameter of 0.289 inch. No one material performed best with all three propellants. Failure by erosion or cracking occurred with each material with at least one propellant. However, certain classes of materials demonstrated superior performance under specific operating conditions. The fully densified refractory-metal nozzles generally were more resistant to erosion and thermal-stress cracking than the other materials. The graphite nozzles performed well with the least oxidizing 5600°F propellant but generally eroded severely with the other propellants. Author

N66-25246 Aerojet-General Corp., Sacramento, Calif.
COOLDOWN OF LARGE-DIAMETER LIQUID HYDROGEN AND LIQUID OXYGEN LINES
J. C. Commander and M. H. Schwartz 20 Apr. 1966 60 p refs
(Contract NAS3-2555)
(NASA-CR-54809; AGC-8800-54) CFSTI: HC $3.00/MF $0.50 CSCL 20M

This report describes the chilldown of large cryogenic systems located in test zone E of the M-1 engine test complex. Theoretical analyses as well as actual experience are included. Author

N66-25323# Deutsche Versuchsanstalt für Luft- und Raumfahrt, Porz (West Germany). Institut fuer Angewandte Gasdynamik.
CONTRIBUTION TO THE DEVELOPMENT OF LIQUID-LEVEL-INDICATION FOR FUEL TANKS FILLED WITH AGGRESSIVE LIQUIDS STANDING UNDER HIGH GAS PRESSURE [BEITRAG ZUR ENTWICKLUNG EINER FULLSTANDSANZEIGE FUR BEHALTER MIT AGGRESSIVEN FLUSSIGKEITEN, DIE UNTER HOHEM GASDRUCK STEHEN]
Josef Thelen, Wolf Trommsdorff, and Herbert Wiegand Feb. 1966 29 p refs In GERMAN; ENGLISH summary
(DVL-468; DLR-Mitt.-66-01) CFSTI: HC $2.00/MF $0.50

This report deals with different methods for measuring the liquid-level in closed fuel tanks. A method with a capacitative probe which seems to be especially qualified for fuel tanks with aggressive liquids standing under high gas pressure is tested in detail. Finally applicabilities for which the introduction of tis method may be of importance are discussed. Author

N66-25527*# National Aeronautics and Space Administration. John F. Kennedy Space Center, Cocoa Beach, Fla.
TECHNIQUES FOR THE REMOTE MONITORING OF HYPERGOLIC PROPELLANT LEAKS
Peter M. Ricca 25 Feb. 1966 30 p
(NASA-TM-X-57519; GP-220) CFSTI: HC $2.00/MF $0.50 CSCL 22D

Techniques for detecting malfunctions in ground support equipment are reviewed with special emphasis on the toxicity hazards provided by hypergolic propellant leakage. Requirements for monitoring toxic gases are discussed, as are means of data collection. The toxic leak detection subsystem proposed for the Saturn V mobile service structure is discussed as a typical detection sensor system, with consideration given to data transmission and display. M.W.R.

N66-25571*# Marquardt Corp., Van Nuys, Calif.
TWO (2) WAY, LATCHING, DC SOLENOID CONTROL VALVE Final Report, 1 Mar.–28 Dec. 1965
R. A. Lynch 3 Jan. 1966 73 p
(Contract NAS9-4069)
(NASA-CR-65340; S-479) CFSTI: HC $3.00/MF $0.75 CSCL 13K

Three two way, latching, dc solenoid control valves suitable for use in hypergolic propellant systems were designed, fabricated, and tested. The valves are intended to isolate reaction control engine clusters from main propellant supply systems in space vehicles. The delivered units incorporate all welded construction to assure minimum external leakage and a fully hermetic seal at the electrical pigtail interface. A summary of demonstrated performance is as follows: (1) internal helium leakage at 360 psig, 0; (2) ΔP at equivalent flow rate of 0.88 pps N_2O_4, 2.55 to 2.90 psi; (3) insulation resistance, greater than 500 megohms/min; and (4) unit weight, 1.565 lbs. D.T.

N66-25608# Utah Univ., Salt Lake City. Dept. of Chemical Engineering.
COMBUSTION IRREGULARITIES IN SOLID PROPELLANTS Final Report, Aug. 1962–Aug. 1963
Norman W. Ryan 4 Mar. 1966 11 p refs
(Grant AF-AFOSR-451-62; ARPA Order 317-62)
(AFOSR-66-0606; AD-630409) CFSTI: HC $1.60/MF $0.50

In studies employing the side-vented end-burner, the participation of the solid phase in acoustic oscillations was quantitatively confirmed and described. In cooperation with other laboratories, the usefulness of the burner for propellant evaluation was demonstrated. Initial experiments in a study of non-acoustic instability were performed. Author (TAB)

N66-26241*# North American Aviation, Inc., Downey, Calif. Space and Information Systems Div.
A STUDY OF LONGITUDINAL OSCILLATIONS OF PROPELLANT TANKS AND WAVE PROPAGATIONS IN FEED LINES. PART V: LONGITUDINAL OSCILLATION OF A PROPELLANT-FILLED FLEXIBLE OBLATE SPHEROIDAL TANK
Shoichi Uchiyama and Clement L. Tai 31 Mar. 1966 58 p refs
(Contract NAS8-11490)
(NASA-CR-74854; SID-66-46-5) CFSTI: HC $3.00/MF $0.50 CSCL 20D

The present study describes an analytical method for determining the axisymmetric longitudinal mode shapes and frequencies of an incompressible and inviscid fluid contained in a pressurized, flexible oblate spheroidal propellant tank. Series expansions for the fluid velocity potential and the tank wall deflections are combined through the boundary conditions and shell equations of motion to obtain an eigenvalue problem whose solutions are the system frequencies and the coefficients of the series. In the analysis, the effect of the ullage gas pressure is included. This program will be directly applied to the present eigenvalue problem for the numerical solutions. Author

N66-26244*# North American Aviation, Inc., Downey, Calif. Space and Information Systems Div.
A STUDY OF LONGITUDINAL OSCILLATIONS OF PROPELLANT TANKS AND WAVE PROPAGATIONS IN FEED LINES. PART IV: LONGITUDINAL OSCILLATION OF A PROPELLANT-FILLED FLEXIBLE HEMISPHERICAL TANK
Henry Wing and Clement L. Tai 31 Mar. 1966 35 p refs
(Contract NAS8-11490)
(NASA-CR-74850; SID-66-46-4) CFSTI: HC $2.00/MF $0.50 CSCL 20D

A procedure has been formulated to determine the natural frequencies of an elastic liquid-filled hemispherical shell subjected to axisymmetric vibrations. It is assumed that the fluid is inviscid and incompressible, and its motion is assumed irrotational. Under these assumptions, a velocity potential is obtained from the solution of Laplace's equation in spherical coordinates. This velocity potential, together with Bernoulli's equation, permits the evaluation of the fluctuating fluid pressure at the interface. Treating the interface pressure as a force function in the shell equations, the shell displacement components are then determined analytically. The free surface boundary condition and the interface condition for the radial velocities can only be satisfied approximately. An eigenvalue problem is formulated by minimizing the integrated squared error for the interface condition subject to the constraints that the integrated error for the free surface condition also be a minimum, and the prescribed radial deflection along the edge of the shell be satisfied. Author

N66-26703*# Republic Aviation Div., Fairchild Hiller Corp., Farmingdale, N. Y.
DEVELOPMENT OF TOOLING, PRODUCTION PROCEDURES, AND PRODUCTION OF 57-INCH BULKHEADS Final Report, Jul. 1964–Dec. 1965
Gunther Pfanner [1965] 99 p
(Contract NAS8-11500)
(NASA-CR-75066; FHR-3232) CFSTI: HC $3.00/MF $0.75 CSCL 13H

Thin 57-inch ellipsoid bulkheads were fabricated in 2219-T6 aluminum alloy for welding into liquid oxygen test tanks. A sequence of fabrication operations involving hydraulic forming, selective chemical milling, heat treatment and contour sizing was developed to obtain close diameter and thickness dimension ranges. The principal development aspects were involved with obtaining forming control of the draw/stretch ratio to avoid buckling or splitting failures. These factors constitute a problem area in aluminum alloys at the high diameter ratio (715:1) of the 57-inch bulkhead blanks. Experimental difficulties were satisfactorily resolved, and a general method of forming control which follows empirical and analytical relationship was evolved. Specific accomplishments include the development of: (1) a segmented pressurized metal bladder for localized control of the workpiece flange, (2) an optimized stretch-draw (or depth-draw) relationship, (3) an inexpensive reinforced fiberglass die concept, (4) a unique hinged flange and pressurization design, and (5) an expandable seal against the moving workpiece surface. Author

N66-27181*# Atlantic Research Corp., Alexandria, Va.
STUDY OF PROPELLANT VALVE LEAKAGE IN A VACUUM Phase II Report, 14 Jan.–7 Mar. 1966
Ralph D. Gift, John A. Simmons, Joseph P. Copeland, Jaydee W. Miller, and Jack M. Spurlock 6 May 1966 112 p refs
(Contract NAS9-4494)
(NASA-CR-65363) CFSTI: HC $4.00/MF $0.75 CSCL 21I

The adverse effects of Aerozine-50 leakage through propellant valves into injector manifolds exposed to a vacuum environment were theoretically and experimentally investigated. A literature survey and mathematical analysis was made to elucidate the freezing characteristics of Aerozine-50. Quantitative relationships between the rate of leakage and the accumulation of frozen propellant within the flow passages of an injector mold were developed. Tests with a simulated injector system were performed to characterize the freezing and its dependency on selected parameters, and to determine the extent of any flow stoppages caused by accumulation of frozen propellant. The test system consisted of a leaky ball valve, a length of glass pipe and a plate with a number of drilled holes, which simulated the propellant valve, manifold, and injector respectively. Results are presented in detail and discussed. Flow-rate, temperature, and pressure data are depicted graphically. L.S.

N66-27229*# General Dynamics/Convair, San Diego, Calif.
ATMOSPHERIC DIFFUSION OF FLUORINE FROM SPILLS OF FLUORINE-OXYGEN MIXTURES Summary Report, 5 Mar. 1965-31 Jan. 1966
10 May 1966 251 p refs
(Contract NAS3-3245)
(NASA-CR-54926; GDC-DDB66-001) CFSTI: HC $7.51/MF $2.25 CSCL 21I

Atmospheric diffusion tests were conducted to determine the plume trajectory and downwind boundary dosages for noncombustive and combustive fluorine spills under a variety of atmospheric conditions. The trajectory of a hot conflagration cloud resulting from spills of up to 3000 lb of a 30 percent LF_2/70 percent LO_2 mixture on fuel was determined by photographic recording and IBM 7094 computation. Two fluorine and two hydrogen fluoride atmospheric samplers in the sensitivity range of 1 to 500 ppm-min by volume were evaluated in field trials. The evaporation rate of liquid LF_2/LO_2 mixture from a simulated spill containment system was determined, and the blast overpressure associated with a LF_2/LO_2 reaction with RP-1 fuel was measured. The capability of Sycamore Test Site for fluorine testing was determined. Author

N66-27413# Pennsylvania State Univ., University Park. Dept. of Fuel Science.
COMBUSTION BEHAVIOR OF THERMOPLASTIC POLYMER SPHERES
R. H. Essenhigh and W. L. Dreier (M.S. Thesis) Mar. 1966 254 p refs
(Contract Nonr-656(29))
(FS66-1; AD-630912) CFSTI: HC $25.00/MF $1.25

The investigation was undertaken to study the combustion behavior of 11 thermoplastic polymer spheres burning in air. They were photographed during combustion so that burning rates could be obtained and compared to calculated values determined through the use of appropriate mass and heat transfer equations. The rates were used as a means of determining whether the polymer sphere combustion system could be compared to the more complex combustion system involved in hybrid rockets that employ polymers as fuels. The polymers appeared to burn in two stages. Polymers with a low carbon content burned almost entirely in a volatile state, characterized by a bright diffusion flame established at some distance from the polymer spehere surface. At volatile burnout, a small amount of residue remained that burned away too rapidly to be measured. The polymers with a high carbon content burned with a quick volatile combustion stage, leaving a carbonaceous residue that burned away slowly with a bright red glow. The volatile burning times, for polymer spheres 0.5 to 1.5 mm in diameter, were between 0.1 and 2.0 seconds while the residue burning time ranged between 1 and 30 seconds. TAB

N66-27574# Aeronutronic, Newport Beach, Calif. Applied Research Labs.
THERMODYNAMIC PROPERTIES OF PROPELLANT COMBUSTION PRODUCTS Second Quarterly Letter Report, 1 Sep.-31 Dec. 1965
N. D. Potter 31 Dec. 1965 8 p refs
(Contract AF 49(638)-1577; ARPA Order 317)
(QLR-66-3; AFOSR-66-0354; AD-630634) CFSTI: HC $1.00/MF $0.50

The objective of this program is to provide thermodynamic data for species which are potentially important combustion products of advanced chemical rockets and for related species. Enthalpy and entropy data are obtained from equilibrium measurements made by torsion-free evaporation and torsion-effusion techniques and by high temperature mass spectrometry. Author (TAB)

N66-27739*# Aerojet-General Corp., Sacramento, Calif. Liquid Rocket Operations.
DEVELOPMENT OF LO_2/LH_2 GAS GENERATORS FOR THE M-1 ENGINE
J. I. Ito 1 Jun. 1966 88 p refs
(Contract NAS3-2555)
(NASA-CR-54812; AGC-8800-59) CFSTI: HC $3.00/MF $0.75 CSCL 21H

The current technology for a 120,000 horsepower liquid oxygen/liquid hydrogen gas generator that was successfully designed and tested for the M-1 engine program is summarized. Nominal gas generator operating conditions for the 8.125-in. diameter and 20-in. long chamber were: 1145 psia chamber pressure, 110.4 lbm/sec flowrate, and 0.80 mixture ratio. A successful coaxial injector design achieved 98% of theoretical combustion efficiency and local gas temperature at the chamber exit varied from 900°F to 1300°F. Limited test data with unbaffled injectors indicated injection velocity ratios (fuel injection velocity/oxidizer injection velocity) of approximately 10 might suppress high frequency combustion instability. Low frequency combustion oscillations, which occurred with a low amplitude during the turbopump development tests with gas generator drive, are also discussed in this report. Author

N66-27746*# Jet Propulsion Lab., Calif. Inst. of Tech., Pasadena.
DEVELOPMENT OF THE POST-INJECTION PROPULSION SYSTEM FOR THE MARINER C SPACECRAFT
Bruce W. Schmitz, Thomas A. Groudle, and James H. Kelley 1 Apr. 1966 53 p refs
(Contract NAS7-100)
(NASA-CR-75553; JPL-TR-32-830) CFSTI: HC $3.00/MF $0.50 CSCL 21H

This report describes the design, development, and operation of the post-injection propulsion system utilized in the Mariner C spacecraft. The propulsion unit consists of a small monopropellant, hydrazine-fueled rocket of 50-lbf vacuum thrust, capable of delivering a variable total impulse in conjunction with a timer-shutoff system. Functionally, the rocket is of the pressure-fed constant-thrust type. Injection pressure is obtained from a compressed gas—nitrogen—that passes through a pressure regulator and forces the propellant from a bladdered tank to the rocket engine. The rocket engine contains a quantity of catalyst to accelerate the decomposition of anhydrous hydrazine. Engine ignition is accomplished through the injection of a small quantity of a hypergolic oxidizer, nitrogen tetroxide. All valving functions for the propulsion unit are accomplished with explosively actuated valves. The propulsion system is capable of two ignitions and thrust terminations. Inflight performance of the propulsion system as a portion of the Mariner III and Mariner IV missions is described. Author

N66-28161# France. Office National d'Etudes et de Recherches Aerospatiales, Chatillon-sous-Bagneux.
PROGRAMMED METHOD FOR THE DETERMINATION OF PROPELLANT CHARACTERISTICS (FROZEN EXPANSION) [METHODE PROGRAMMEE DE CALCUL DES PERFORMANCES DE PROPERGOLS (DETENTE FIGEE)]
Bernard Crampel, Simone Barrère, and M. Paule Lemaitre
1965 139 p ref In FRENCH; ENGLISH summary
(TN-91(1965)) CFSTI: HC $4.00/MF $1.00

A computer method was developed to determine the characteristics of rocket propellants, assuming a frozen expansion. The calculation of the equilibrium composition of multiphased chemical systems was used as a subroutine; this permits the evaluation of propellants consisting of up to twenty elements. The detailed working conditions of the program are described; and the general organization of the program is given. In addition, the Fortran vocabulary and the symbolic program are presented. D.T.

N66-28840# Bureau of Mines, Pittsburgh, Pa. Explosives Research Center.
DROP-WEIGHT TESTING OF EXPLOSIVE LIQUIDS
Charles M. Mason, Robert W. Van Dolah, and Milton L. Weiss
1966 23 p refs
(BM-RI-6799)

The Bureau of Mines evaluated equipment and procedures for drop-weight testing of explosive liquids as prescribed by Test 4, a widely used method. It was demonstrated that partial ignitions, originally designated as negative results, should be designated positives; it was also shown that wear or erosion of the sample cups and the type of mount used for the apparatus had important effects on the results. Relative sensitivity as measured by Test 4 was found to vary slightly with temperature. The Bureau also designed a fixed 2-kg weight and associated electromagnetic release, which subsequently were incorporated as standard in a revision of Test 4. The original concept that the test involves only adiabatic compression was found to be an oversimplification; an alternate mechanism for the initiation process is proposed in which due consideration is given to the effects of cavitation and microjets. Author

N66-28922# Auburn Univ., Ala. Dept. of Chemistry.
A STUDY OF THE DECOMPOSITION MECHANISM OF AMMONIUM PERCHLORATE Quarterly Report, 1 Jan.–31 Mar. 1966
James E. Land [1966] 13 p refs
(Contract DA-01-021-AMC-12346(Z))
(QR-3; AD-631593) CFSTI: HC $1.00/MF $0.50

Data are recorded for the differential thermal analysis (DTA) of samples of mole parts of ammonium perchlorate mixed with mole parts of metal perchlorates in either 95/5 or 99/1 ratio. The runs were made to determine the influence of the additive on the DTA exo- and endotherms recorded for the decomposition of the ammonium perchlorate as it is heated at various rates over a given temperature range. The perchlorates used for doping the ammonium perchlorate were those of copper, lead, potassium, cadmium, zinc, manganese, silver, barium, magnesium, sodium, and iron. TAB

N66-29070*# National Aeronautics and Space Administration. Marshall Space Flight Center, Huntsville, Ala.
PREDICTION OF PROPELLANT TANK PRESSURIZATION REQUIREMENTS BY DIMENSIONAL ANALYSIS
J. F. Thompson and M. E. Nein Washington, NASA, Jun. 1966 21 p refs
(NASA-TN-D-3451) CFSTI: HC $1.00/MF $0.50 CSCL 21H

A general equation, based on a dimensional analysis of a number of pressurization tests, was derived in order to predict pressurant gas mass requirements for cylindrical and spheroidal liquid oxygen and hydrogen propellant tanks. The equation is accurate to within ±10%. It is noted that the method is primarily intended for preliminary design and optimization studies in which the use of large computers becomes excessive in cost and time. D.T.

N66-29202# Indiana Univ., Bloomington. Dept. of Chemistry.
SPECTROMETRIC STUDIES OF FAST REACTIONS Final Report
Edward J. Bair [1966] 11 p refs
(Contract AF 49(638)-1257)
(AFOSR-66-0596; AD-631787) CFSTI: HC $1.10/MF $0.50

The project was undertaken in order to develop and demonstrate new spectroscopic procedures for studying both the detailed path and the elementary processes of photolytically initiated explosions similar in some respects to combustion reactions which also proceed by free radical and energy chain processes. Following the development of a highly reproducible reaction system, different spectroscopic features of the same system are studied by repeating the reaction. Special precautions to ensure that the system is homogeneous tend to isolate the chemical dynamics part of the combustion problem from the fluid dynamics part. With long absorption path and low dample pressure the time resolution of the measurements is reasonably comparable with the time between intermolecular collisions. A fast, high resolution spectrometer specifically designed for this work resolves transient energy features such as the rotational fine structure of free radical absorption with a time resolution of about a microsecond. In the photolytic explosion of ozone the time dependence of the ozone concentration, ozone vibrational energy, vibrational energy of the oxygen product in levels up to 23 and the rotational-kinetic temperatures were correlated. In the photolytic explosion of hydrazine the relative time dependence of NH_2 radicals, NH radicals, hydrazine and a new transient spectrum not yet fully identified were compared. Author (TAB)

N66-29290*# General Dynamics/Convair, San Diego, Calif.
THE CENTER VENT SHAPE FOR VENTING A TANK IN A LOW GRAVITY ENVIRONMENT
C. K. Perkins 25 Jul. 1961 24 p ref
(NASA-CR-72006; GD/C-66-D-859) CFSTI: HC $1.00/MF $0.50 CSCL 22B

Existing computations and liquid/liquid model tests have demonstrated the general zero-g equilibrium configuration of the Centaur upper-stage fuel-tank ullage. This report contains calculations and some discussion of the effect of the center-vent tube on this ullage-bubble configuration. The equilibrium shape about a two-inch tube is calculated. It appears that the liquid/gas interface will be displaced about 2.3 inches below the uppermost bubble surface. Because this effect is so small, it is concluded that, with certain restrictions, the simple center tube will make a practical vent. Author

N66-29292*# General Dynamics/Convair, San Diego, Calif.
CENTAUR TANK CORROSION TESTS AND X-RAYS
1 Aug. 1965 147 p refs
(Contract NAS3-3232)
(NASA-CR-72000; GD/C-BNZ-65-032) CFSTI: HC $4.00/MF $1.00 CSCL 20K

It is found that tank corrosion can be deterred or prevented by the following method; (1) elimination of the corrosive elements from the tank fabrication processes; (2) fabrication of the tank under stringently clean conditions, and the providing of protection from contamination during storage; and (3) the application of a corrosion inhibitor to the outside surfaces of the tank structure and to the parts and assemblies as early in the fabrication process as is compatible with manufacturing operations. The effectiveness of these measures was demonstrated by the low quantity of corrosion found on Centaur tanks 7D, 8D, and 9D. Author

N66-29471*# Aerojet-General Corp., Azusa, Calif.
STUDY OF PRESSURIZATION SYSTEMS FOR LIQUID PROPULSION ROCKET ENGINES Final Report, 19 Apr. 1961–15 Sep. 1962
F. W. Childs, T. R. Horowitz, W. Jenisch, Jr., and B. Sugarman
15 Sep. 1962 120 p refs *Its* Rept.-2335
(Contract NAS5-1108)
(NASA-CR-52780) CFSTI: HC $4.00/MF $0.75 CSCL 21H
(Declassified)

This report presents the results of a comprehensive study to devise a selection technique for propellant pressurization systems. As a result, the likely propellant pressurization systems for advanced space vehicles were determined, and a method of preliminary design and selection of the most suitable of these systems for any specific space mission was provided. Author

N66-29689# Air Force Inst. of Tech., Wright-Patterson AFB, Ohio. School of Engineering.
AN INVESTIGATION OF THE PERFORMANCE OF VARIOUS MIXTURES OF HYDROGEN AND METHANE
Clyde William McLaughlin (M.S. Thesis) Mar. 1966 89 p refs
(GAM/ME/66A-6; AD-632387) CFSTI: HC $3.00/MF $0.75

The primary purpose of this study was to evaluate the performance of various mixtures of hydrogen and methane as a fuel with oxygen as an oxidizer. A computer program was used to provide the theoretical results at a chamber pressure of 60 psia and mixture ratios from 1.5 to 5.0. The fraction of methane in the fuel was varied from 0 to 1.0. Experimental results were obtained by using a small reverse flow rocket engine and three separate propellant feed systems with a mixing chamber to combine the hydrogen and methane prior to the gases entering the fuel manifold of the rocket. A nonlinear degradation of characteristic exhaust velocity was found as the fraction of methane in the fuel was increased. The degradation with all methane as the fuel was 77% of the pure hydrogen–oxygen performance. Experimentally, the combustion efficiency was found to decrease with an increasing percentage of methane in the fuel. Author (TAB)

N66-29969*# Air Reduction Co., Inc., Murray Hill, N. J. Research and Engineering Dept.
TOFLOX SYNTHESIZER STUDY Final Report, May 27, 1965–Jan. 31, 1966
John J. Sima 13 May 1966 126 p
(Contract NAS8-20099)
(NASA-CR-76071; RE-66-085-CRE-36) CFSTI: HC $4.00/MF $1.00 CSCL 13H

Equipment has been developed for the pilot production of 0.05–0.10% O_3F_2 in LO_2 (TOFLOX) in 25 gal. batch quantities. The equipment, now being operated at Huntsville, demonstrates that TOFLOX can be made reliably and safely on an engineering scale. This report contains information necessary for the operation and maintenance of that equipment. Author

N66-29993# Picatinny Arsenal, Dover, N. J. Plastics Technical Evaluation Center.
COMPATIBILITY OF PLASTICS WITH LIQUID PROPELLANTS, FUELS AND OXIDIZERS
Norman E. Beach Jan. 1966 126 p refs
(PLASTEC-25; AD-632287) CFSTI: HC $4.00/MF $0.75

Much has been published on the subject of the compatibility of plastics with liquid propellants, fuels and oxidizers, but invariably from the standpoint of the propellant or fuel. This report is a rearrangement of the published compatibility data from the standpoint of the plastic material. It is in the form of a tabulation, with primary arrangement by plastic (or elastomeric) material; and thereunder, by fuel. All arrangements are alphabetical, in the form given in the original reference; that is, either by generic or trade designation. The compatibility evaluation is in terms of the original document, briefly culled to show behavior of the material at a given temperature and for a given time. Elastomers are included; but oils, lubricants and greases are omitted, even though based on polymers. The information has been drawn from 43 references, which are annotated so that the information extracted from them shall have additional significance. Author (TAB)

N66-30490*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
COMPATIBILITY OF POLYMERIC MATERIALS WITH FLUORINE AND FLUORINE–OXYGEN MIXTURES
Louis M. Russell, Harold W. Schmidt, and Larry H. Gordon Washington, NASA, Jun. 1966 41 p refs
(NASA-TN-D-3392) CFSTI: HC $2.00/MF $0.50 CSCL 11I

Compatibility tests were performed on a number of polymeric materials with the use of various mixtures of fluorine and oxygen in both gaseous and liquid states to investigate the feasibility of using fluorine–oxygen mixtures in rocket-propulsion systems containing some nonmetallic materials. In the static tests, a number of test samples were exposed to various FLOX (fluorine–oxygen) mixtures, both gaseous and liquid, at atmospheric pressure and virtually static conditions in order to obtain information on compatibility solely as a function of fluorine concentration. In the dynamic tests, selected materials were exposed to fluorine and FLOX at various combinations of concentration and flow velocity. Reactivity profiles were generated for these materials as functions of these two parameters. Generally the fluorocarbon polymers, particularly the fully fluorinated, straight-chain polymers were the most compatible with fluorine and with FLOX. In both static and dynamic tests, a comparison between cryogenic liquid and ambient-temperature gaseous test results indicated that the liquid was the more reactive. It was concluded that some of the materials tested may be considered for use in rocket systems with fluorine or FLOX under controlled conditions of exposure. Author

N66-30615*# Mathematical Sciences Corp., Seattle, Wash.
FLEXIBLE CASE ANALYSIS FOR COMPRESSIBLE SOLID PROPELLANT GRAIN MOTORS Status Report
Samuel W. Key Apr. 1966 25 p
(Contract NAS7-242)
(NASA-CR-76229; MSC-66-21-1) CFSTI: HC $1.00/MF $0.50 CSCL 21I

The stiffness version of the finite element method is used for a flexible numerical analysis o' the small elementary regions of solid propellant grains. Similar to the Ritz method, the stiffness variations analyzes grain regions independent of the total configuration and combines the results to determine the response of the total configuration. An equivalent variational principle replaces conventional equilibrium equations and stress boundary conditions. For a plane strain problem and an axisymmetric elasticity problem, triangular rings are used; in the axially symmetric shell problem, line elements are employed. While the theory underlying the stiffness method is sufficiently general to include three-dimensional problems, the current practice is to utilize two-dimensional problems because programming and computer capacity is generally unavailable for the former. Details are included for both a plane strain problem and an axisymmetric problem bounded by a flexible case. M.W.R.

N66-30702# School of Aerospace Medicine, Brooks AFB, Tex.
EFFECTS OF HYDRAZINE ON BLOOD GLUCOSE AND MUSCLE AND LIVER GLYCOGEN IN THE ANESTHETIZED DOG Progress Report, Mar.-Nov. 1964
Gale D. Taylor (M.S. Thesis—Texas A&M Univ.) Mar. 1966 16 p refs
(SAM-TR-66-13; AD-633164) CFSTI: HC $1.00/MF $0.50

Intravenous injection of diluted hydrazine (25 mg./kg.) into anesthetized dogs caused prompt elevation of blood glucose levels, which reached a maximum in about 2 hours and decreased progressively during 4 hours thereafter. Liver glycogen levels fell rapidly during the first 4 hours after injection of hydrazine. Depletion of liver glycogen stores was associated with severe hypoglycemia and some depletion of muscle glycogen. Packed cell volume progressively increased after hydrazine administration. Microscopic examination of liver tissue from treated dogs showed swelling of hepatic cells and apparent fatty infiltration. Sections of liver stained with PAS confirmed the rapid glycogen depletion. It is postulated that hydrazine affects the carbohydrate concentration of various tissues by a primary insult to the glycogenetic-glycogenolytic mechanism of the liver. Author (TAB)

N66-30758*# Jet Propulsion Lab., Calif. Inst. of Tech., Pasadena.
OPTIMIZATION OF SYSTEM OPERATING PARAMETERS FOR HEAT STERILIZABLE LIQUID PROPULSION SYSTEMS
Howard D. Curtis and Allen D. Harper 1 Jun. 1965 35 p ref
(Contract NAS7-100)
(NASA-CR-76318; JPL-TM-33-211) CFSTI: HC $2.00/MF $0.50 CSCL 21H

As a means of attaining a sterile spacecraft, design information is required for liquid propulsion systems which can be heat sterilized in the loaded condition without venting. An analysis was performed to determine the values of the system operating parameters which minimize the system mass. Results are presented for both internally and externally pressurized tankage systems. The tankage mass for sterilizable systems is approximately twice that for nonsterilizable systems. This will mean an increase of 5 to 10% in propulsion system mass for typical applications. The tankage mass is minimized when the tank is 60 to 70% filled with propellants (prior to heating) in the externally pressurized case and approximately 40% filled in the internally pressurized case. Author

N66-30857*# Goodyear Aerospace Corp., Akron, Ohio.
DEVELOPMENT OF A LIGHTWEIGHT CRYOGENIC INSULATING SYSTEM Final Report, 30 Jun. 1964–31 May 1966
R. A. Burkely, A. H. Kariotis, F. D. Yoder, J. N. Apisa, P. Kost et al May 1966 240 p refs
(Contract NAS8-11761)
(NASA-CR-76368; GER-12269) CFSTI: HC $6.00/MF $1.25 CSCL 13H

This final report documents a 23-month effort to develop and perfect advanced lightweight panel insulation systems capable of providing efficient and highly reliable thermal protection when applied externally to cryogenic propellant tanks of launch vehicles. The primary effort was expended on the development of materials and fabrication techniques associated with 9 dual-seal cryogenic insulation concept. Thermal and structural characteristics of selected panel constructions were defined by liquid hydrogen tankage tests on a large oval-shaped tank. Author

N66-31138# Naval Radiological Defense Lab., San Francisco, Calif.
THE RADIOLYTIC DECOMPOSITION OF HYDROZINE, RP-1, AND HYDYNE ROCKET FUELS
W. E. Shelberg 6 Mar. 1966 17 p refs
(USNRDL-TR-1002; AD-6322461) CFSTI: HC $1.00/MF $0.50

One-hundred-milliliter samples of the storable liquid rocket fuels hydrazine, RP-1, and Hydyne generate, respectively, 89.1, 50.3 and 149.4 ml of radiolytic off-gas (measured at 25°C and 1 atm) when irradiated to 86,000,000 rads with gamma rays. When approximately 5 wt-% of an efficient, olefinic, free-radical scavenger is added to the samples, the off-gas volume produced by RP-1 fuel is reduced by 18.7% while those of hydrazine and Hydyne fuels are not reduced. These scavenging effects show that RP-1 fuel decomposes radiolytically by both free-radical (18.7%) and molecular mechanisms, and that hydrazine and Hydyne fuels decompose entirely by a molecular or ionic mechanism. Author (TAB)

N66-31267# Stanford Research Inst., Menlo Park, Calif.
IGNITION OF SIMULATED PROPELLANTS BASED ON AMMONIUM PERCHLORATE
W. A. Rosser, N. Fishman, and H. Wise 30 Jul. 1965 35 p refs
(Contract Nonr-3415(00))
(PU-3573; AD-619067) CFSTI: HC $2.00/MF $0.50

The ignitability of simulated solid propellants based on NH_4ClO_4 was studied using the radiation from an arc image furnace as a source of ignition energy. The experimental measurements provide (for given conditions) the minimum time of exposure to radiation required for ignition and combustion of pellets pressed from powdered mixtures of NH_4ClO_4 and copper chromite; NH_4ClO_4 carbon, and copper chromite; and NH_4ClO_4 copper chromite, and polyethylene. Minimum exposure times were determined as a function of pellet composition, flux (20 to 120 cal/cm^{2}sec), pressure (1 to 40 atm), and composition of the atmosphere N_2, He, A) in contact with the pellet. The experimental results in conjunction with supplementary kinetic information indicate that, for these materials, gas phase ignition need not be preceded by a catastrophic rate of heat release within the sample. The critical chemical species involved during gas phase ignition is probably perchloric acid. Under some circumstances, a high rate of solid reaction does appear to be involved during ignition of the materials. Author (TAB)

N66-31379*# International Business Machines Corp., Rockville, Md. Federal Systems Div.
LIQUID LEVEL SENSOR SYSTEM FOR CRYOGENIC PROPELLANTS Final Report
18 Mar. 1966 291 p refs
(Contract NAS8-11774)
(NASA-CR-76401) CFSTI: HC $6.00/MF $1.50 CSCL 14B

A prototype engineering model propellant level sensor system consisting of an electronics unit and a propellant probe was designed, constructed, and tested. The electronics unit uses a base band pulse reflection technique implemented by high-speed sampling methods to sense the propellant liquid level. The propellant probe is a light-weight twin lead transmission line driven from a very broad-band balun. Author

N66-31421*# National Aeronautics and Space Administration. Marshall Space Flight Center, Huntsville, Ala.
ASPECTS OF ZERO LEAKAGE TECHNOLOGY
P. G. Hass *In its* Proc. of the Conf. on the Design of Leak-Tight Fluid Connectors [1965] p 1-2 (See N66-31420 18-15) CFSTI: HC $6.00/MF $1.25

The present technology concerning fluid connectors for launch and spacevehicles is reviewed, and the future design criteria are described. It is pointed out that for future space vehicles, the allowable leakage will be reduced to a value like 10^{-6} cc/s. A separable connector concept using semipermanent joints designed not to be taken apart and reassembled more than 3 or 4 times is discussed. Environmental requirements are indicated as operating pressures to 6000 psi, extension of temperature range to 1500°F, and duct diameters up to 18 inches. N.E.N.

N66-31432*# General Electric Co., Daytona Beach, Fla. Apollo Support Dept.
LEAKAGE DETECTION AND MEASUREMENT
R. I. Ceder-Brown *In* NASA. Marshall Space Flight Center Proc. of the Conf. on the Design of Leak-Tight Fluid Connectors [1965] p 89-97 (See N66-31420 18-15) CFSTI: HC $6.00/MF $1.25

The sensors discussed are divided into three groups for specific gas applications: (1) hydrogen sensors, (2) oxygen sensors, and (3) non-specific sensing methods. The discussion of the sensors presents general characteristics of commercially available sensors and is followed by scope of work on recent research and developments in leak detection. Author

N66-31435*# National Aeronautics and Space Administration. Marshall Space Flight Center, Huntsville, Ala.
THE DEVELOPMENT OF A NEW CRYOGENIC GASKET FOR LIQUID OXYGEN SERVICE
James E. Curry and William G. Scheck (Whittaker Corp.) *In its* Proc. of the Conf. on the *Design of Leak-Tight Fluid Connectors* [1965] p 117-128 refs (See N66-31420 18-15) CFSTI: HC $6.00/MF $1.25

A research and development program was conducted to develop a plastic gasket material compatible with liquid oxygen that would be superior to the gaskets presently being used for Saturn space vehicle applications. A laminated gasket composite of Teflon and glass was developed. This gasket composite was tested at 75°, −320°, and −423° F= The conclusion was that 500 psi of helium gas pressure could be contained by this gasket. The major advantage of this gasket composite is that it is flexible and requires no retorquing of the bolts due to cold flow as exhibited by various other materials. Author

N66-31436*# Martin Co., Denver, Colo.
DESIGN AND DEVELOPMENT OF AN ELASTOMER SEAL FOR LONG TERM HAZARDOUS PROPELLANT STORAGE
J. P. Marcus, W. A. Day, and J. G. Jelinek (Parker Seal Co.) *In* NASA. Marshall Space Flight Center Proc. of the Conf. on the Design of Leak-Tight Fluid Connectors [1965] p 129-144 refs (See N66-31420 18-15) CFSTI: HC $6.00/MF $1.25

Containment of storable, chemically active missile propellants under long term storage conditions has normally been accomplished using stainless steel or special aluminum mechanical joints with all metal or plastic/metal gaskets. The containment of the oxidizer, nitrogen tetroxide using the above mentioned joint configurations has been problematical. An intensive effort has been carried out to develop and incorporate more effective mechanical joint configurations for the Titan II ICBM. This program has resulted in the qualification of a set of elastomer seals previously considered unsuitable for the application in N_2O_4. This paper presents the details of the design and development of these seals for long term containment of N_2O_4. Author

N66-31928*# Union Carbide Corp., Bound Brook, N. J. Polymer Research and Development Dept.
SATURATED HYDROCARBON POLYMERIC BINDER FOR ADVANCED SOLID PROPELLANT AND HYBRID SOLID GRAINS Quarterly Report No. 2, 1 Feb.–30 Apr. 1966
James E. Potts, ed., A. C. Ashcraft, Jr., E. M. Sullivan, and E. W. Wise [1966] 23 p *Prepared for JPL*
(Contracts NAS7-100; JPL-951210)
(NASA-CR-76476) CFSTI: HC $1.00/MF $0.50 CSCL 20I

Ethylene-neohexene prepolymers were prepared using the organic peroxides succinic acid peroxide and glutaric acid peroxide. These initiators result in acid terminated prepolymers which are quite high in viscosity considering their molecular weights. Esterification of the acid end groups results in a drastic decrease in viscosity, which is attributed to elimination of hydrogen bonding association. Functionalities approaching two carboxyl groups per molecular have been obtained based on molecular weight determinations in benzene. Molecular weight determinations in polar solvents such as tetrahydrofuran yield functionalities closer to one. Diethyl α,α'-azobisisobutyrate has been prepared and its kinetics of thermal decomposition measured at 100°C. This initiator has been used to make three copolymerizations which proceeded very smoothly. The products are being hydrolyzed and characterized. Author

N66-32114*# Martin Co., Denver, Colo.
PRESSURIZATION SYSTEM FOR USE IN THE APOLLO SERVICE PROPULSION SYSTEM Interim Report
D. N. Gorman and G. R. Page Jul. 1965 252 p refs
(Contract NAS9-3521)
(NASA-CR-65314; CR-65-50) CFSTI: HC $3.75/MF $1.50 CSCL 21H

In the development of an advanced, lightweight, fuel-tank pressurization system for use in the Apollo service propulsion system, three candidate systems were designed and analyzed; a single system was selected as a prototype for subsequent testing. Experimental results showed that gas molecular weight could be reduced from 4 to 2 by replacing helium with hydrogen. It was found that systems utilizing hydrazine monopropellant gas generator gases as fuel tank pressurants are very efficient from a weight standpoint, and that a weight reduction of 370 pounds can be achieved by reducing the gas storage temperature of an Apollo-like system to 37°R. The cascade concept of introducing warmer helium directly in to the storage tank is considered to be the lightest method of increasing residual gas temperature and thereby residual mass. It was pointed out that the incorporation of the cascade system into the Apollo service would result in a 535-pound weight savings; since this was considered satisfactory from every other aspect examined, it is the recommended system. R.LI.

N66-32316*# Bell Aerosystems Co., Buffalo, N. Y.
PHOTOGRAPHIC INVESTIGATION OF PROPELLANT STREAM BEHAVIOR IN A FIRING ROCKET ENGINE, VOLUME II Technical Summary Report, 1 Aug. 1964–28 Feb. 1966
T. G. Rossman, R. N. Eulner, and L. M. Wood 24 Jun. 1966 69 p *Its* Rept.-9136-950001
(Contract NAS8-11364)
(NASA-CR-76722) CFSTI: HC $2.50/MF $0.75 CSCL 21B

A series of photographs are presented which show the behavior of propellant streams emerging from the injector face of a rocket motor. Also included are diagrams of the propellant distribution, the test apparatus, and the optical systems used for the shadowgraph photography. E.A.O.

N66-32923*# Rocketdyne, Canoga Park, Calif. Research Dept.
FLUORINE-HYDROGEN PERFORMANCE EVALUATION. PHASE I, PART I: ANALYSIS, DESIGN, AND DEMONSTRATION OF HIGH PERFORMANCE INJECTORS FOR THE LIQUID FLUORINE-GASEOUS HYDROGEN COMBINATION Final Report
H. A. Arbit and S. D. Clapp Aug. 1966 224 p refs
(Contract NASw-1229)
(NASA-CR-54978; R-6636-1) CFSTI: HC $3.75/MF $1.25 CSCL 21H

Two injectors were designed for use with an uncooled, segmented, calorimetric thrust chamber (L^*=30-inches) designed for 2500-pound thrust (vacuum, ϵ-60) at the midpoint of the experimental matrix (chamber pressure=100 psia, mixture ratio=12). One was a triplet pattern in which LF_2 doublets impinged upon a central showerhead GH_2 jet; and the other employed self-impinging LF_2 doublets, with showerhead GH_2 jets on each side of the spray fan. Particular attention was given to the procedures used to obtain the experimental data, and analyses were presented covering their reliability and precision. Redundant measurements were made of all important parameters and characteristic velocity was calculated by two independent methods, one based on chamber pressure and the other on thrust. The performance of both injectors are discussed in terms of the degree of liquid atomization which they produce. Heat transfer results are considered in terms of the relative magnitudes of the three sources of chamber wall heat flux: convection, radiation, and recombination. C.T.C.

N66-33176*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
THE X-IRRADIATION OF HYDRAZINE AND 1,1-DIMETHYLHYDRAZINE
Harold Lucien and Murray L. Pinns 18 Sep. 1964 13 p refs Submitted for Publication
(NASA-TM-X-54848) CFSTI: HC $1.00/MF $0.50 CSCL 07C

Hydrazine and 1,1-dimethylhydrazine were irradiated at room temperature in both the liquid and the vapor phase with 0.1 to 1.0 Å X-rays at intensities of 1×10^2 to 1×10^3 roentgens per minute and with total doses up to 2.3×10^6 rads. This resulted in 0.3- to 31-percent decomposition with decreasing sensitivity to X-radiation as follows: hydrazine vapor, 1,1-dimethylhydrazine vapor, 1,1-dimethylhydrazine liquid, and hydrazine liquid. Author

N66-33180*# Michigan Univ., Ann Arbor. Heat Transfer and Thermodynamics Lab.
PRESSURIZATION OF LIQUID OXYGEN CONTAINERS Progress Report No. 7, Nov. 1963–Nov. 1964
J. A. Clark, H. Merte, Jr., W. J. Yang, E. Lewis, H. Barakat et al Jan. 1965 81 p refs *Its* Rept.-04268-9-P
(Contract NAS8-825)
(NASA-CR-63431) CFSTI: HC $3.00/MF $0.75 CSCL 20M

During this period a summary of the subject of pressurization, stratification, and interfacial phenomena was completed. The test vessel and test procedures followed in obtaining subcooled nucleate boiling data of liquid nitrogen under fractional gravity and free fall conditions are described. Data are presented in the film boiling region from a disc with a vertical orientation, horizontal facing downward, and horizontal facing upward. The effects of pressure, subcooling, gravity, and orientation are noted. Modifications to the test facility for use with liquid hydrogen are described. A power series solution is obtained for the temperature field in the field in which a spherical bubble is growing as a result of a step change in the boundary movement and/or translatory velocity of the bubble. Bubble growth rates are obtained for the quasi-steady small acceleration and large acceleration cases. The two-dimensional laminar transient free convection heat and mass transfer in cylindrical containers is analyzed using a numerical method which is briefly described. Results obtained for the flow patterns at two different time levels are given. R.N.A

N66-33309*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
PERFORMANCE OF JP-4 FUEL WITH FLUORINE–OXYGEN MIXTURES IN 1000-POUND-THRUST ROCKET ENGINES
Donald L. Nored and Howard W. Douglass Washington, NACA, 11 Jun. 1958 35 p refs
(NACA-RM-E58C18) CFSTI: HC $2.00/MF $0.50 CSCL 21I (Declassified)

Seven injectors of four different types were tested for use with JP-4-oxygen–fluorine propellant combinations. High characteristic velocities were obtained over the complete range of 0- to 70-percent fluorine in the oxidant. Combustion pressure in the water cooled thrust chambers was 600 pounds per square inch absolute. The same basic injection requirements apparently prevail for fluorine-rich oxidants as for pure oxygen where simultaneous atomization and mixing of the propellants gave the most favorable results, and atomization along yielded better performance than mixing alone. A triplet injector (atomization with mixing) gave the highest performance and was efficient over wide ranges in oxidant-fuel ratio. However, the design of triplet units seems to be critical. Minor design changes in oxidant orifices resulted in significant shift in performance. Variation in arrangement of triplet units on injector faces greatly influenced the heat transfer rates through the engine walls. A like-on-like injector creating finely divided atomization depended less on engine length for good performance than a triplet injector having coarser sprays. Author

N66-33332*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
INVESTIGATION OF SMALL-SCALE HYDRAZINE-FLUORINE INJECTORS
R. James Rollbuhler and William A. Tomazic Washington, NASA, Jan. 1959 17 p refs
(NASA-MEMO-1-23-59E) CFSTI: HC $1.00/MF $0.50 CSCL 21H (Declassified)

The performance of the liquid-hydrazine–liquid-fluorine propellant combination was investigated in nominal-300-pound-thrust uncooled rocket engines with different injectors. Data are presented for characteristic velocity as a function of weight percent fuel flow. All tests were made at a chamber pressure of 300 pounds per square inch absolute. The injectors, showerehead, like-on-like, and triplet types, were made of individual elements which could be used as "building blocks" in fabricating larger thrust injectors. The highest performance was obtained with triplet injectors. A maximum characteristic velocity of 6690 feet per second (94 percent of theoretical equilibrium) was reached at 36 weight percent fuel flow. In none of the runs was there any corrosion or erosion of the injectors, either from the propellants or combustion heat flux. There was no problem from hydrazine decomposition, propellant ignition, or combustion oscillation. Author

N66-33333*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

INVESTIGATION OF INJECTORS FOR A LOW-CHAMBER-PRESSURE HYDROGEN-FLUORINE ROCKET ENGINE

Harold G. Price, Jr., Robert J. Lubick, and Arthur M. Shinn, Jr. Washington, NASA, Jul. 1962 30p refs

(NASA-TM-X-485) CFSTI: HC $2.00/MF $0.50 CSCL 21H (Declassified)

Characteristic velocity efficiencies as high as 99 percent were obtained with gaseous hydrogen and liquid fluorine in short combustion chambers with a throat area of 12 sq in. Data covered a combustion-pressure range of 20 to 60 lb/sq in. abs (nominally 333 to 1000 lb thrust) and a fuel-by-weight range of 6 to 12 percent. Low-pressure-drop coaxial and shower-heat injectors were used; the best over-all results were obtained with a coaxial injector having five injector elements per sq in. of face area. Changing the number of injection elements, the chamber length, or the degree of propellant mixing affected performance. Some low-frequency combustion instabilities were observed which were believed to be associated with the flow system characteristics. Author

N66-33344*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

EXPERIMENTS WITH HYDROGEN AND OXYGEN IN REGENERATIVE ENGINES AT CHAMBER PRESSURES FROM 100 TO 300 POUNDS PER SQUARE INCH ABSOLUTE

William A. Tomazic, Edward R. Bartoo, and R. James Rollbuhler Washington, NASA, Apr. 1960 39p refs

(NASA-TM-X-253) CFSTI: HC $2.00/MF $0.50 CSCL 21H (Declassified)

Tests were made with hydrogen and oxygen in regenerative thrust chambers of lightweight construction designed to give 20,000-pound thrust at a chamber pressure of 300 lb/sq in. abs and sea-level exhaust. Showerhead type injectors were used. Data were obtained at chamber pressures of 300, 150, 125, and 100 lb/sq in. abs over a mixture range from 10 to 23 percent fuel. Specific impulse for all pressures ranged from 93 to 98 percent of the theoretical for equilibrium expansion. The highest value obtained was 335 pound-seconds per pound at 300 lb/sq in. abs and 22 percent fuel. Average overall heat-transfer rates varied from 2.0 to 6.3 Btu/(sq in.)(sec) and closely matched calculated values. The experiments totaled 13 minutes of operation with chambers constructed of stamped channels which were brazed and wrapped with wire. Damage to the inner walls was experienced only during runs at 300 lb/sq in. abs. Low-frequency oscillations (approx. 100 cps) were obtained during operation at 100 to 150 lb/sq in. abs. These oscillations did not cause chamber damage. Author

N66-33454*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

EXPERIMENTAL ROCKET PERFORMANCE OF APOLLO STORABLE PROPELLANTS IN ENGINES WITH LARGE AREA RATIO NOZZLES

Carl A. Aukerman and Arthur M. Trout Washington, NASA, Aug. 1966 45p refs

(NASA-TN-D-3566) CFSTI: HC $2.00/MF $0.50 CSCL 21I

The performance of nitrogen tetroxide and a blend of 50% hydrazine and 50% unsymmetrical dimethyl hydrazine was evaluated at a chamber pressure of 100 lb/sq in. absolute in rocket engines with large area ratio nozzles which produced 8000 to 9000 lb. of thrust. Two contoured nozzles with area ratios of 60 to 40 plus a 15° conical nozzle with an area ratio of 60 were operated at mixture ratios between 1.4 and 2.2. Tests were also run with 1.3-area-ratio nozzles to determine the most reliable and accurate method of separating internal performance between the combustion chamber and supersonic nozzle. Improvement of nozzle performance was attempted by injecting a catalytic fluid and analytically by recontouring the supersonic portion. The maximum delivered vacuum impulse at a mixture ratio of 2.0 was 320 sec for the conical nozzle and 318 for the scaled Apollo Service Module nozzle with an area ratio of 60. Experimental thrust coefficients indicated that some equilibrium flow existed and the net value could be predicted by aerodynamic and chemical reaction kinetic analysis. Nozzle performance was unaffected by characteristic velocity variations and combustion instability. The attempts to improve performance were unsuccessful. Pressure measurements in the combustion chamber were very unreliable in calculating chamber or nozzle performance. Impulse measurements with a low area ratio nozzle to calculate c* efficiency was the most reliable and accurate method. Author

N66-33494*# Vickers, Inc., Troy, Mich. Research and Development Dept.

DEVELOPMENT OF A PROPORTIONAL TWO STAGE PRESSURE FEEDBACK PNEUMATIC VALVE FOR 2000°F SOLID PROPELLANT SYSTEMS Report, Jul. 6, 1965–May 20, 1966

Jul. 1966 121p refs

(Contract NAS1-4102)

(NASA-CR-66156) CFSTI: HC $3.00/MF $1.00 CSCL 13K

Secondary flow amplification was applied for control of high primary pneumatic mass flows independent of extraneous internal valve flow and mechanical forces. Closed loop pressure feedback logic was incorporated to achieve functional static accuracy and dynamic response. Six flightweight prototype models were fabricated and then tested in both gaseous nitrogen and 2000°F pneumatic supply environments. An analog analytical study provided design parameters to optimize the dynamic response characteristics and flightweight design criteria. Analog investigations included scaled mass flow, system pressure levels, and capability potential for 5500°F solid propellant systems. Materials and design stress investigations were included for 5500°F systems. It is concluded that the concept of a flightweight proportional two-stage valve incorporating closed loop pressure feedback logic for high temperature solid propellant pneumatic systems is practical. Author

N66-33660# Naval Ordnance Lab., White Oak, Md. Advanced Chemistry Div.

THE DETONATION BEHAVIOR OF HYDRAZINE MONONITRATE

Donna Price, T. P. Liddiard, Jr. and R. D. Drosd 15 Apr. 1966 21p refs

(NOLTR-66-31; AD-634602) CFSTI: HC $1.00/MF $0.50

Data obtained some time ago on the detonation velocity (D)-loading density (ρ_0)-charge diameter (d) relationships of hydrazine mononitrate were reassessed. They are reported in detail for the first time. The infinite diameter curve is D(mm/microsec) = 5.388 (ρ_0)-0.100, where ρ_0 is in g/cc. At finite diameters of 1.27 to 4.14 cm, the D vs ρ_0 curves exhibit maxima. This behavior is to be expected of explosives whose critical diameter increases with increasing loading density, the reverse of the trend exhibited by common explosives such as TNT. Hydrazine mononitrate can therefore be classified as belonging to a group of explosives showing the atypical behavior described. Author (TAB)

N66-33674*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
STORAGE AND HANDLING OF CRYOGENIC FLUIDS
Donald L. Nored, Glen Hennings, Donald H. Sinclair, Gordon T. Smith, George R. Smolak et al *In its* Selected Technol. for the Petrol. Ind. 1965 p 125–153 (See N66-33666 19-34) GPO: HC $1.25; CFSTI: MF $0.50

Technology pertinent to the general use of cryogenic fluids is discussed, with emphasis on cryogenic propellants. Properties of fluids at 1 atmosphere are listed, and the propellant production and handling are described. The special technology connected with structural materials for cryogenic temperatures, and their changes due to low temperatures are described. Characteristics of metals and fiber glass filament wound composites are presented. Insulation of tanks is discussed, and sensors for temperature, pressure, and liquid level measurements are described. N.E.N.

N66-33714*# TRW Systems, Redondo Beach, Calif.
CHEMICAL SPECIES AND CHEMICAL REACTIONS OF IMPORTANCE IN NONEQUILIBRIUM PERFORMANCE CALCULATIONS
P. I. Gold 11 Oct. 1965 41 p refs
(Contract NAS9-4358)
(NASA-CR-65442; TRW-5435-6005-TU-000) CFSTI: HC $2.00/MF $0.50 CSCL 21B

Significant chemical species and reactions in typical propellant exhaust mixtures containing carbon, hydrogen, oxygen, nitrogen, fluorine, chlorine, and one metal element, either aluminum, beryllium, boron, or lithium, were determined for consideration in nonequilibrium performance calculations. The propellant systems were selected as representative of typical liquid rocket cryogenic, space storable and prepackaged storable, hybrid and solid types. Significance of the various propellant systems was established through elimination, by repeated equilibrium and frozen performance calculations. Further reduction was accomplished by studying all possible recombination–dissociation and binary exchange reactions and eliminating those highly improbable. A literature survey to determine the status of rate data for chemical reactions was performed, and the results are included. Data resulting from each step of the study are presented in tabulated form. K.W.

N66-33746# Aerospace Medical Div. Aerospace Medical Research Labs. (6570th), Wright-Patterson AFB, Ohio.
AEROSPACE TOXICOLOGY RESEARCH
Anthony A. Thomas *In* AGARD Collected Papers Presented at the 22d Meeting of the AGARD Aerospace Med. Panel Sep. 1965 p 259–278 refs (See N66-33726 19-04) CFSTI: HC $5.93/MF $2.75

Three major areas of aerospace toxicology research are discussed briefly. In propellant toxicology, emphasis is focused on characterizing tolerance to high level, short duration exposure, and on establishing emergency tolerance limits (ETL) for missile operators. Consideration is also given to beryllium toxicity and the differences in response of the lung tissue between various animal species. Environmental pollution research includes laboratory and greenhouse studies involving all newly synthesized propellants and combinations of fuels and oxidizers. Such propellants, propellant ingredients, and combustion products are listed, and summary data are presented on fumigation studies of hydrazine, unsymmetrical dimethylhydrazine, and nitrogen dioxide. The environmental toxicology of space cabins is also under study. Details are given on an inhalation exposure facility for determining the effects of low atmospheric pressure and oxygen rich atmospheres on the characteristics of uninterrupted long term exposure to toxic gases and vapors encountered in space cabin atmospheres. M.G.J.

N66-33760*# Weather Bureau, Washington, D. C.
METEOROLOGICAL CONSIDERATIONS IN THE HANDLING OF A MIXTURE OF LIQUID FLUORINE AND LIQUID OXYGEN
Richard K. Siler 15 Oct. 1964 49 p refs Prepared for NASA
(NASA-CR-62579; AD-608118) CFSTI: HC $2.00/MF $0.50 CSCL 04B

A general climatology for those weather elements pertinent to the use of a mixture of liquid fluorine and liquid oxygen for the Cape Kennedy–Merritt Island area is presented, and questions regarding flourine behavior in the atmosphere are outlined. The physical and chemical properties of flourine and its applicable compounds are discussed. Some of the problems that could arise from flourine introduction into the atmosphere are delineated, and recommendations toward possible solution of these problems are offered. The general nature of the diffusion of a gas in the atmosphere and a climatology pertinent to this problem is described briefly. In the absence of weather observations from Merritt Island, some speculations on possible differences in the weather on Cape Kennedy and on Merritt Island are given. A.G.O.

N66-34154# Princeton Univ., N. J. Guggenheim Labs. for the Aerospace Propulsion Sciences.
THE HOMOGENEOUS GAS PHASE KINETICS OF REACTIONS IN THE HYDRAZINE–NITROGEN TETROXIDE PROPELLANT SYSTEM
Robert F. Sawyer 1965 339 p refs *Its* Tech. Rept.-761
(Contract AF 49(638)-1268)
(AFOSR-66-0855; AD-634277) CFSTI: HC $7.00/MF $1.25

A number of different homogeneous gas phase reactions arising from the possible combinations of the fuels: hydrazine, ammonia, hydrogen, and decomposed hydrazine with the oxidizers: nitrogen dioxide, oxygen, nitric oxide, and decomposed nitrogen dioxide were investigated in the same adiabatic flow reactor at temperatures falling between 800°K and 1300° K. Heats of reaction, reaction orders, and reaction rates were determined. From the measured reaction rates, Arrhenius rate constants were calculated and overall activation energies determined. Based on the experimental observations and the work of other investigators on related reactions, reaction mechanisms were postulated. Author (TAB)

N66-34208*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

EXPERIMENTAL INVESTIGATION OF BAFFLE EFFECTIVENESS IN A CONFINED FLUID SUBJECTED TO WALL AND NONUNIFORM SOURCE HEATING

Thomas John Biesiadny (M.S. Thesis—Purdue Univ.) Aug. 1966 66 p refs

(NASA-TM-X-52236) CFSTI: HC $2.50/MF $0.75 CSCL 20M

Heating of liquid hydrogen in the propellant tank of a nuclear rocket was simulated in a two dimensional view tank with and without baffles present. A mixture of trichoroethane and ethyl alcohol was used to represent the liquid hydrogen. Infrared rays from quartz lamps were used to produce the two types of heating required. The tanks were subjected to similar heating conditions with and without baffles, and visual information concerning fluid behavior was obtained using schlieren photographs. Fluid temperatures were measured using thermocouples. Baffles were found to be quite effective during the early portion of each transient run and throughout most of the transient period for each run carried out with a low wall heating rate. With a sizeable rate of nonuniform source heating present, the effectiveness of the baffles was decreased as compared with their effectiveness under similar conditions but in the absence of source heating. Author

N66-34412# Douglas Aircraft Co., Inc., Santa Monica, Calif.

SOME THERMAL ASPECTS OF A CONTAINED FLUID IN A REDUCED-GRAVITY ENVIRONMENT

S. H. Schwartz and M. Adelberg *In* Lockheed Missiles and Space Co. Fluid Mech. and Heat Transfer under Low Gravity [1965] 47 p refs (See N66-34408-20-12) CFSTI: HC $7.70/MF $2.25

A survey of the various factors affecting heat transfer to a liquid in a container is made emphasizing their effect on pressure buildup prediction in cryogenic propellant tanks. The various heat-transfer modes are reviewed and examined in terms of the magnitudes of the acting forces. Critical values of force ratios are developed. The prediction of the conditions under which the inception of boiling will occur is considered. Utilizing laminar and turbulent flow analyses, the location on a vertical wall where the critical temperature is reached is defined as a function of the heat flux and gravity level. A more precise method is also presented. Summary plots indicating the heat-transfer domains are included. Since the transient time period for the sudden heating of a vertical wall is large in the low-heat-flux low-g regime, equations are presented to estimate the transient periods for non-boiling turbulent flow and for boiling flow. Also, other factors involved in the analysis of practical stratification problems are considered, including the critical wall angle where instability effects result and the point where conduction is of the same magnitude as convection. Existing computer programs for handling stratification are reviewed. Modifications for extending their usefulness are discussed. Author

N66-34531# Research Triangle Inst., Durham, N. C. Natural Products Lab.

THE PREPARATION OF SMALL RING COMPOUNDS CONTAINING SILICON. PART I: VINYL-HYDROGEN LIGAND EXCHANGE ON SILICON. PART II: THE PREPARATION AND ISOMERIZATION OF MONOCYCLIC SILYLHYDRAZINES. PART III: ON THE ATTEMPTED SYNTHESIS OF THE 1, 2-DISILACYCLOBUTANE RING SYSTEM Technical Report, Jun. 1965–Jun. 1966

Colin G. Pitt, Kenneth R. Skillern and Glenn L. Roof Jun. 1966 29 p refs

(Contract Nonr-4860(00))

(TR-1; AD-634735) CFSTI: HC $2.00/MF $0.50

The first example of vinyl-hydrogen ligand exchange at silicon, catalyzed by chloroplatinic acid, is described. The disproportionation of tri-p-tolylsilane to di-p-tolylsilane and tetra-p-tolylsilane is shown to occur without isomerization to ortho, meta, or benzyl isomers. The aluminum chloride catalyzed fragmentation of bis-1,2-(dimethylchlorosilyl) ethane and 1-triethylsilyl-2-dimethylchlorosilylethane is reported. The preparation of 3,3,6,6-tetramethyl-1,2-diaza-3,6-disilacyclohexane and 1-amino-2,2,5,5-tetramethyl-1-aza-2,5-disilacyclopentane is described. The two compounds are shown to be in equilibrium at room temperature even in the absence of catalysts. 1,2-bis(trimethylsilyl)hydrazine is shown to be in equilibrium with 1,1-bis(trimethylsilyl)hydrazine, although thermal equilibration is relatively slow. The preparation of the 1,2-disilacyclobutane ringing system was attempted by: (1) ring closure of bis-1,1-(chlorosilyl)ethanes with various metals and (2) oxidation of 3,3,6,6-tetramethyl-1,2-diaza-3,6-disilacyclohexane and 1-amino-2,2,5,5-tetramethyl-1-aza-2,5-disilacyclopentane with mercuric oxide and ethyl azodicarboxylate. The products obtained from these oxidations have been characterized and their formation discussed. Author (TAB)

N66-34701*# Jet Propulsion Lab., Calif. Inst. of Tech., Pasadena.

REVIEW OF SOLID PROPELLANTS FOR SPACE EXPLORATION

Frank J. Hendel 1 Oct. 1965 23 p refs

(Contract NAS7-100)

(NASA-CR-77354; JPL-TM-33-254) CFSTI: HC $1.00/MF $0.50 CSCL 21I

Various families of solid propellants which are or could be used in space vehicles and spacecraft are reviewed. These include polyurethane, polybutadiene–acrylic acid, polybutadiene–acrylic acid–acrylonitrile, carboxyl-terminated polybutadiene, double base, and thermoplastic polymers as fuel and binders of the crystalline oxidizers with or without aluminum or beryllium powder. Future solid propellants will have improved physical properties and specific impulse. Improved specific impulse will result from the use of energetic oxidizers, such as lithium ozonide, energetic fuel-binders such as nitropolymers and acetylenic polymers, and energetic fuel ingredients such as light metal hydrides. An ultra-energetic cryogenic solid propellant could be made by freezing a mixture of liquid oxygen and hydrogen or a light metal hydride. A "cold" solid propellant made from BeH_2 and frozen hydrogen peroxide will have a theoretical vacuum specific impulse of almost 500 sec. Author

N66-34799*# North American Aviation, Inc., Downey, Calif. Space and Information Systems Div.

A STUDY OF PROPELLANT BEHAVIOR AT ZERO GRAVITY Final Report

E. T. Benedikt 15 Apr. 1966 120 p refs

(Contract NAS8-11097)

(NASA-CR-77358; SID-66-286) CFSTI: HC $4.00/MF $1.00 CSCL 20I

Results of an analytical and experimental study of the behavior of liquids under conditions of zero gravity are presented. A general analytical method has been formulated for the prediction of the kinematics of a liquid having a free surface and subjected to the joint action of gravitational, surface, and interfacial tension forces, as well as to the effects of an arbitrary translational motion imparted to the tank. The general formulas were specialized for application to the case of liquid in a cylinder subjected to axial and lateral forced translations. An automatic numerical procedure was developed for the integration of the equations of motion of the liquid. A concurrent experimental program provided data for verification of the analytical method. A comparison of observed and computed results provides satisfactory agreement within the computational accuracy maintained. Problems of heat transfer and boiling are discussed. Author

N66-34867# Rocket Propulsion Establishment, Westcott (England).
THE DISSOCIATION ENERGY OF THE N-H BOND IN HYDRAZINE AND RELATED COMPOUNDS
I. P. Fisher London, Min. of Aviation, Dec. 1965 22 p refs
(RPE-TR-65/11; AD-634219) CFSTI: HC $1.00/MF $0.50

There are, currently, two values proposed for the N-H bond dissociation energy in hydrazine. Arguments are presented in favor of the lower value. Bond strengths, heats of formation and ionization potentials of radicals related to the hydrazyl radical are derived. Author (TAB)

N66-34902# Ballistic Research Labs., Aberdeen Proving Ground, Md.
MEASUREMENT OF TEMPERATURE PROFILES IN BURNING SOLID PROPELLANT
Richard C. Strittmater, H. E. Holmes, and L. A. Watermeier Mar. 1966 24 p refs
(BRL-MR-1737; AD-635188) CFSTI: HC $1.50/MF $0.50

A technique is presented for synchronizing a high speed motion picture record of a small thermocouple emerging from a burning surface with the temperature record from the thermocouple. Experimental results are presented which show the burning surface temperature of M13 double base propellant to be 535°C at 200 psig. A heat loss analysis is presented which indicates that the thermocouples used in this study, and in fact, all thermocouples used in temperature profile measurement in burning solid propellants have given temperatures much too low. Suggestions are made for measurement technique which would yield more accurate results. Author (TAB)

N66-34935*# TRW Systems, Redondo Beach, Calif.
INVESTIGATION OF RESIN FOR IMPROVED ABLATIVE MATERIALS Final Report, 19 Jun. 1964–31 Jul. 1965
H. R. Lubowitz, E. A. Burns, and B. Dubrow 1 Apr. 1966 219 p refs
(Contract NAS3-4188)
(NASA-CR-54471; TRW-4176-6014-50-000) CFSTI: HC $3.75/MF $1.25 CSCL 11I

Work performed to advance the state-of-the-art of resin matrices required for improved ablative materials for use with high energy fluorine-containing liquid propellant systems is described. Critical resin properties which influence the effectiveness of ablative composites were determined analytically in order that criteria could be established for the synthesis and property testing of new and modified resins. Several new polymer systems with improved properties were proposed, evaluated and recommended for future study. Poly (cyclized 1, 2-polybutadiene) tolyl urethane ladder polymers, poly alkaline earth metal acrylates, phosphate bonded oxides, modified polyimides and several other organic and inorganic systems were conceived and/or evaluated during this program to meet the property requirements identified analytically. Author

N66-35514*# North American Aviation, Inc., Downey, Calif. Space and Information Systems Div.
A PRELIMINARY LOGISTICS BURDEN MODEL FOR THE PRODUCTION OF LUNAR ORES
Carl B. Hayward 15 Aug. 1964 *In* Acad. Proc. of the Working Group on Extraterrest. Resources [1965] p 289–311 refs (See N66-35506 21-30) CFSTI: HC $8.50/MF $2.75

This report of a preliminary study attempts to establish a logistic burden model for lunar mining and ore dressing to support the production of water, oxygen, and other logistically important life-support and propellant substances from lunar rock. Mining methods and equipment are sensitive to many factors, and perhaps the most important of these is the required production rate. This study, therefore, is based on system production ratings of ten and one hundred times a modular unit (M) equivalent to 9 lb/hr of water or 8 lb/hr of oxygen. The mining concept upon which the study is based involves the use of chemical explosives and one or more special mining machines which, with one exception, are all vehicular in nature. Initial mining efforts are presumed to be surface operation. Conclusions include the logistic burden rates for capital equipment, consumable supplies, electric power, and manpower—all expressed as a function of the production order of magnitude. Author

N66-35516*# National Aeronautics and Space Administration. Marshall Space Flight Center, Huntsville, Ala.
ECONOMIC ANALYSIS OF EXTRATERRESTRIAL PROPELLANT MANUFACTURE IN SUPPORT OF LUNAR EXPLORATION
David Paul, III 15 Nov. 1965 *In* AF Acad. Proc. of the Working Group on Extraterrest. Resources [1965] p 341-376 refs (See N66-35506 21-30) CFSTI: HC $8.50/MF $2.75

Economic considerations, affecting a transport or manufacture decision concerning the resupply of propellants for use in lunar exploration operations, are developed and analyzed. Factors are suggested which will be prerequisites to an economic justification for the manufacture of propellants from lunar resources. This paper presents a postulated extrapolation of a lunar surface activities framework, establishes therefrom a demand estimate, considers a number of lunar resource processing concepts, and establishes the economic break-even conditions between transport and manufacture modes of resupply. Parametric results are presented which will permit basic decisions to be formulated concerning the desirability, from an economic view-point, of planning for lunar propellant manufacture as an adjunct to advanced lunar operations. In particular, the analysis concentrates on the use of propellant manufacture to support crew rotation flights from the lunar station to Earth (preliminary analyses have designated this as a most promising area for concentration). This paper will support a first order answer to the question of economic feasibility related to lunar propellant manufacture within the lunar exploration era of lunar activities. Author

N66-35517*# General Dynamics/Fort Worth, Tex.
SPACE TRANSPORTATION LOGISTIC REQUIREMENTS COMPARISON UTILIZING LUNAR MANUFACTURED PROPELLANTS
R. A. Gorrell and J. B. Deodati *In* AF Acad. Proc. of the Working Group on Extraterrest. Resources [1965] p 377–398 refs (See N66-35506 21-30) CFSTI: HC $8.50/MF $2.75

The economic feasibility of utilizing lunar produced propellants is considered for Earth orbital, Lunar base, and Mars-lander missions. Various refueling modes in Earth orbit, lunar orbit, and lunar surface are investigated and propellant demand rates for each mission/refueling mode combination are determined. Lunar production and storage facilities requirements are investigated and base personnel and logistics support requirements are assessed. Saturn V launch vehicles and logistic payload time-sequences for mission support are developed. A comparison is made of the effectiveness of performing the various missions with and without the use of lunar produced propellants in terms of total Earth launch requirements. The improvement in effectiveness as a function of time and the number of missions performed is assessed. Sensitivity effects are evaluated and conclusions are drawn regarding the more promising concepts for utilizing lunar propellants. Author

N66-35544# Princeton Univ., N. J. Guggenheim Labs. for the Aerospace Propulsion Sciences.
NON-STEADY COMBUSTION OF SOLID PROPELLANTS WITH SPECIAL REFERENCE TO ROCKET INSTABILITY *Annual* **Technical Report, 1 Oct. 1964–30 Sep. 1965**
Herman Krier, Gerald di Lauro, Lubomyr Kurylko, and Martin Summerfield Mar. 1966 38 p refs *Its* Aerospace and Mech. Sci. Rept.-773
(Contract AF 49(638)-1405)
(AFOSR-66-1099; AD-634986) CFSTI: HC $2.00/MF $0.50

A prominent mode of coupling that may drive a solid-propellant rocket motor into instability is the interaction between the oscillatory gas dynamic pressure at the burning surface and the instantaneous rate of the oscillatory pressure fluctuations and of rapid monotonic pressure increases are being investigated in a continuing program. Two pieces of apparatus are in use for this purpose. One is the T-tube oscillator. The latter is a chamber with a device to change suddenly on command the throat area of the nozzle to produce pressure rise times of 8,000 psi per second and less. This low range supplements the higher range achievable in the T-tube oscillator. The chamber has three quartz windows which allow luminosity measurements and high speed motion pictures of the propellant flame to be made along with chamber pressure, by varying the chamber volume, and thereby the dp/dt, luminosity versus pressure can be obtained as a function of dp/dt. From this, the temperature is plotted as a function of pressure and dp/dt, and therefore the entropy is plotted as a function of the same variables. The brightness-emissivity method of instantaneous flame temperature measurement is being used. Experiments are being conducted to determine the flame temperature as a function of pressure in various regimes of dp/dt. Author (TAB)

N66-35660*# TRW Equipment Labs., Cleveland, Ohio.
BIPROPELLANT PULSED ENERGY TURBOALTERNATOR POWER SYSTEM DEVELOPMENT Final Report, Sep. 1, 1965–Jul. 14, 1966
Aug. 1966 191 p refs
(Contract NAS9-4820)
(NASA-CR-65499; ER-6917) CFSTI: HC $3.25/MF $1.75 CSCL 10B

A turboalternator, gas generator and associated controls were designed. Three turboalternator units, four gas generators and one controls unit were fabricated. Turboalternator Unit #1 was tested for the purpose of system and facility integration. After preliminary tests, endurance tests were conducted on Unit #1. Power output, propellant consumption, coast times, and critical temperatures were obtained from the endurance tests. System performance was analyzed at various power levels and at two oxidizer/fuel (O/F) ratios. Analysis indicated an SPC of 11.9 lb/KW-HR at an equivalent electrical load of 3 KW at the DC terminals and an SPC of 11.1 lb/KW-HR at 4.5 KW at the DC terminals. In two instances while testing Unit No. 1, laboratory scavenge pump stoppages resulted in overloading the alternator and bearings with oil. Operation at 35 to 40 shaft H.P. for 4 to 5 secs. occurred before shut down. Pulses occurred each second during this period with no damage to the unit. At other times operation with partial oil starvation for short periods resulted in no bearing or seal failures. In the early development tests, altitude chamber temperatures up to 500°F were encountered with resultant Moog valve seat damage. Author

N66-35778*# National Bureau of Standards, Boulder, Colo. Cryogenic Data Center.
CRYOGENIC DATA CENTER ACTIVITIES *Semiannual* **Progress Report, 1 Jan.–30 Jun. 1966**
V. J. Johnson, R. B. Stewart, and N. A. Olien 30 Jun. 1966 24 p refs
(NASA Order R-06-006-046)
(NASA-CR-77574; NBS-9254) CFSTI: HC $1.00/MF $0.50 CSCL 20L

Progress of the data evaluation and compilation efforts on the following tasks is reported: (1) Thermodynamic properties of hydrogen in the solid, liquid, and gaseour phases from 4° to 300°K (this work includes consideration of the ortho-para and isotopic modifications); (2) Thermodynamic properties of oxygen (compilation work completed); (3) Thermodynamic properties of argon in the solid, liquid, and vapor phases from 20° to 300°K; (4) Saturation and fixed point properties of cryogenic fluids for the liquid-vapor, solid-vapor, and solid-liquid transitions; (5) Viscosity and thermal conductivity of cryogenic fluids; and (6) Physical equilibria and thermodynamic and transport properties for binary mixtures of the cryogenic fluids. Included are sample T-S and P-Z charts for oxygen and sample tables of viscosity for oxygen and nitrogen. The Documentation Unit reports that distribution of the Weekly Current Awareness Service has increased from about 350 copies per week to nearly 1000; that new assessions increased 47% over the previous period with 4348 items being processed in this six months period; and that there has been 73% increase in bibliographic searches with 38 major searches completed. During this period a total of 821 orders were filled with 5938 items, a 3% increase over the previous period. The report includes a summary chart for the status of data compilation tasks, a list of thermodynamic charts that have been prepared and a list of 30 publications and reports issued by the Crygenic Cryogenic Data Center. Author

N66-35792*# Chrysler Corp., New Orleans, La. Space Div.
QUALIFICATION TEST OF SATURN S-IB STAGE LOX REPLENISHING VALVE /60C20457/
R. M. Dale 9 Jun. 1965 80 p refs
(Contract NAS8-4016)
(NASA-CR-77656; TR-RE-65-54; AD-483718L) CFSTI: HC $3.00/MF $0.75 CSCL 13K

Qualification tests were carried out a Saturn S-IB stage LOX two-inch, nominal diameter, bidirectional replenishing ball valve 60C20457. The valve weighs ten lbs and measures 7×8.8×9 inches. It is spring loaded, and opened by a pneumatic control piston assembly (it is normally closed). Tests conducted included: (1) flow chamber and control piston proof pressure, (2) functional, (3) dielectric strength, (4) high temperature, (5) humidity, (6) salt spray, (7) vibration, (8) impact shock, (9) life cycle and (10) flow chamber and control piston burst tests. Valve 60C20457 met the qualification requirements of procurement specification 60C26012, with the exception of shaft seal leakage. The rms finish of the shafts for the tested samples failed to meet vendor drawing requirements. When reworked to meet or exceed the finish requirements, the leakage stopped. Photographs of the valve, valve components, and test set-ups are given; and data sheets are included. L.S.

N66-35933*# National Aeronautics and Space Administration. Langley Research Center, Langley Station, Va.
VACUUM EFFECTS ON SOLID-PROPELLANT ROCKET FUEL

John P. Mugler and James M. Bradford *In* NASA. Lewis Res. Center High-Vacuum Technol., Testing, and Meas. Meeting Aug. 1966 p 193–196 (See N66-35906 21-11) CFSTI: HC $6.00/MF $1.50

Measurements of outgassing rates for polyurethane and PBAA fuels are presented as part of a program to study effects of vacuum on solid propellant rocket fuel. The rate of pressure rise technique was used to measure outgassing rates as a function of vacuum exposure time. Outgassed products of both polyurethane and PBAA were identified by a time-of-flight mass spectrometer installed in the chamber. A mass spectrogram of polyurethane after 160 hours in vacuum shows water as the main outgassing product; however the spectrum for PBAA after 180 hours shows hydrocarbons as the main constituents. S.P.

N66-35949*# Union Carbide Plastics Co., Bound Brook, N. J. Polymer Research and Development Dept.
SATURATED HYDROCARBON POLYMERIC BINDER FOR ADVANCED SOLID PROPELLANT AND HYBRID SOLID GRAINS Quarterly Report No. 3, 1 May–31 Jul. 1966
J. E. Potts, ed., A. C. Ashcraft, Jr., E. M. Sullivan, and E. W. Wise [1966] 32 p refs Prepared for JPL
(Contracts NAS7-100; JPL-951210)
(NASA-CR-77796) CFSTI: HC $2.00/MF $0.50 CSCL 11A

The new technique of gel permeation chromatography was used to determine the molecular weight distributions of a wide variety of ethylene–neohexene copolymers. The ratic $\overline{M}_w/\overline{M}_n$ was found to be between 1.2 and 1.5 for the samples studied. The data accumulated in this study provide strong reasons for preferring molecular weight data obtained in polar solvents such as tetrahydrofuran, to similar data obtained when non-polar solvents are used. Molecular distillation is effective for fractionating ethylene–neohexene copolymers in the molecular weight range of 200–800. The fractions so obtained have very narrow molecular weight distributions. DEAB has been used to make several additional polymerization runs. Techniques have been worked out for the hydrolysis of these products, whose complete characterization is still in progress. Dimethyl α,α'-azobisisobutyrate (DMAB) has been synthesized from readily available materials in a four step synthesis with an overall yield of 58%. Author

N66-35960*# United Aircraft Corp., East Hartford, Conn. Research Labs.
ANALYTICAL STUDY OF CATALYTIC REACTORS FOR HYDRAZINE DECOMPOSITION Quarterly Progress Report No. 1, 15 Apr.–14 Jul. 1966
A. S. Kesten Jul. 1966 20 p refs
(NASA-CR-77763; E910461-3) CFSTI: HC $1.00/MF $0.20 CSCL 21I

Work is reported in the preparation of equations comprising the steady-state microscopic model of a distributed-feed catalytic reaction chamber in a form amenable to numerical solution. An iterative procedure was developed to solve the implicit integral equations describing reactant concentration and temperature profiles in the porous catalyst particles. Numerical methods were developed for the simultaneous solution of these equations with the equations describing the variation of reactant concentrations and temperature with axial position in the interstitial phase. A computer program utilizing these procedures is being written. Reduction of the equations comprising the transient macroscopic model to a form amenable to numerical solution was initiated. Overall transport coefficients were used to define the driving forces for heat and mass transfer in terms of the temperature and concentration difference between the interstitial phase and the gas phase in the interior of the catalyst particles. Author

N66-36216# Stanford Research Inst., Menlo Park, Calif. Polymer and Propulsion Sciences.
RESPONSE OF A BURNING PROPELLANT SURFACE TO EROSIVE TRANSIENTS Quarterly Report No. 1, 1 Jan.–31 Mar. 1966
E. L. Capener, Lionel A. Dickinson, and G. A. Marxman 22 Apr. 1966 24 p refs
(Contract AF 49(638)-1665)
(AFOSR-66-0938; AD-634296) CFSTI: HC $1.00/MF $0.50

It was previously found that the heat release in the solid phase was associated with the driving process of unstable combustion. Since most of the propellants of interest are based on ammonium perchlorate (which has been shown to endow propellants with instability), it was considered necessary to identify the processes which could attenuate acoustic waves. A study of loss mechanism demonstrated that end losses are significant and enhance both axial and transverse stability. In the case of axial instability the enhanced heat transfer to the end closure was examined using heat transfer gauges. Theoretical studies are continuing in an attempt to integrate combustion response to the gas dynamics of the cavity. Author (TAB)

N66-36548# Florida Univ., Gainesville.
A MATHEMATICAL MODEL FOR DEFINING EXPLOSIVE YIELD AND MIXING PROBABILITIES OF LIQUID PROPELLANTS
E. A. Farber *In* Canaveral Council of Tech. Soc. 3d Space Congr. 1966 p 510–519 refs (See N66-36506 22-30)
(Contract NAS10-1255)

This paper describes how a mathematical model can be constructed to fit theoretical or experimental data on yield and spill of liquid propellants. It shows how these primary quantities can be separated, how probability distributions can be found for each, and how probability confidence regions and confidence limits can be established. The fundamental function of this very general mathematical model, based upon four independent parameters, and the characteristics of the resulting probability surface are discussed in detail. The mathematical model, programmed for an IBM 709 computer, is applied to some spill test data of liquid propellants for which the necessary information is available and then with a minimum number of assumptions to missile failure yield estimates. Author

N66-36549# National Aeronautics and Space Administration. John F. Kennedy Space Center, Cocoa Beach, Fla.
A SYSTEMATIC APPROACH FOR THE ANALYTICAL ANALYSIS AND PREDICTION OF THE YIELD FROM LIQUID PROPELLANT EXPLOSIONS
E. A. Farber (Florida Univ.) and J. H. Deese *In* Canaveral Council of Tech. Soc. 3d Space Congr. 1966 p 530–532 refs (See N66-36506 22-30)
(Contract NAS10-1255)

This paper presents a systematic approach by which the expected yield from liquid propellants can be predicted and furthermore gives an insight into the physical phenomena involved. The yield potential and the mixing function can be determined allowing for the type of propellants, their relative proportions, the reaction rates between the components depending upon mixture composition, the heat transfer rates between the components and the propellants and the surroundings, the mode of failure and the resulting mixing characteristics, and the ignition and reaction delay times. Combining the above information into seven charts as presented leads to a systematic analytical determination of the expected yield. Author

N66-36800*# Colorado State Univ., Fort Collins.
PROPELLANT FROM SPENT TANKAGE

William R. Mickelsen *In its* Advanced Elec. Propulsion Res. 30 Jun. 1966 7 p refs (See N66-36794 22-28) CFSTI: HC $6.00/MF $1.25

An investigation is presented of the feasibility of using spent tankage as a possible source of propellant for electric spacecraft. Chemical rocket propellant tanks are expected to be made of aluminum because of its superior fracture resistance at cryogenic temperatures. It melts at a reasonably moderate temperature (932°K) for conversion to the vapor state, and could then be fed into electric thrustors as propellant. A precise evaluation of performance gains is made in a simple, closed-formed analysis, and shows that the greatest gains are obtained for the more difficult missions. C.T.C.

N66-36906# School of Aerospace Medicine, Brooks AFB, Tex.

PHARMACOLOGY AND TOXICOLOGY OF PROPELLANT FUELS—BORON HYDRIDES

James H. Merritt Jun. 1966 13 p refs *Its* Rev. 3-66
(AD-636910) CFSTI: HC $1.00/MF $0.50

The effects of boron hydrides on animals and humans are described, and methods of treatment are discussed. Since boranes have strong electron-acceptor properties and are good reducing agents, they react with NH_3, organic amines, unsaturated hydrocarbons, various heterocyclic amines, and other compounds, including those of biological origin. Diborane, pentoborane, and decaborane are readily absorbed through the skin and by inhalation, and are particularly toxic to the central nervous system. Neurologic symptoms are the most prominent feature of pentaborane intoxication, while decaborane has produced performance decrements of reinforced tasks in the monkey. In addition to CNS disturbances, the boron hydrides produce cardiovascular effects and damage to both liver and kidney. The cardiovascular effects, as well as certain of the autonomic effects, are similar to those produced by reserpine. Glucose tolerance curves, similar to those in diabetes, are produced by decaborane and boron hydride derivative fuel. Therapy of boron hydride intoxication has been empirical with drugs used to control convulsions. Methylene blue, a stable oxidizing agent, has been found effective after decaborane exposure. E.A.O.

N66-37020# Los Alamos Scientific Lab., N. Mex.

PROJECT ROVER LIQUID HYDROGEN SAFETY: A FIVE YEAR LOOK

T. E. Ehrenkranz [1965] 15 p refs Presented at the Cryogenic Eng. Conf., Boulder, Colo.
(Contract W-7405-ENG-36)
(LA-DC-7689; CONF-660605-2) CFSTI: HC $1.00/MF $0.50

Large scale use of liquid hydrogen has been associated with Project Rover at Jackass Flats, Nevada, since 1959. There were misadventures; these, together with the advice of specialists led to continuing improvements in procedures and equipment. Main components of the liquid hydrogen system are described; incidents and the lessons learned are related and the gradual refinement of safety devices and procedures are traced. It is felt today that standing operating procedures, control over incompatible operations, room inerting, remote control of high hydrogen flow rates and proven equipment reliability make the main contributions to carrying out large scale liquid hydrogen operations with confidence. Author (NSA)

N66-37139*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

COMPARISON OF PROPELLANT SLOSHING PARAMETERS OBTAINED FROM MODEL AND FULL-SIZE CENTAUR LIQUID-OXYGEN TANKS

Andrew J. Stofan Washington, NASA, Sep. 1966 14 p refs (NASA-TM-X-1286) CFSTI: HC $1.00/MF $0.50 CSCL 21I

Propellant sloshing and pendulum analogy parameters are compared for a scale-model and a full-scale Centaur liquid-oxygen tank. Experimental data were obtained in a 1/3.75 scale-model tank and a full-size tank in both an unbaffled and a baffled configuration with water as the contained liquid. The full-size baffled tank configuration was also tested with liquid oxygen as the contained liquid. The fundamental-frequency and damping-ratio parameters show good agreement between the scale-model and full-size tanks for both the unbaffled and baffled tank configurations. The fundamental-frequency and damping-ratio parameters for the baffled tank configuration show no apparent difference between liquid oxygen and water. The pendulum analogy parameters, obtained for the unbaffled tank configuration only, also show good agreement between the model and full-size tanks. Author

N66-37162# United Technology Center, Sunnyvale, Calif. Research and Advanced Technology Dept.

COMPOSITE SOLID PROPELLANT IGNITION MECHANISMS Annual Scientific Report, 1 Apr. 1965–31 Mar. 1966

Larry J. Shannon May 1966 59 p refs
(Contract AF 49(638)-1557)
(UTC-2138-ASRI; AFOSR-66-0935; AD-484048)

Investigation of composite propellant ignition in a shock tube by conductive heating from a doubly compressed stagnant gas has shown that formulation variables exhibit little influence on ignition times in the presence of oxygen. Surface roughness was shown to have a strong influence on ignition times. Ignition time was found to be independent of the manner in which oxygen concentration was changed, i.e., by variation of mole fraction or total pressure. Extension of the hypergolic ignition theory to include adsorption and desorption processes provided a foundation for qualitative and quantitative analysis of the oxygen data. High-speed photographic investigation of composite propellant ignition in an arc-image furnace produced interesting qualitative information. Gasification of what appears to be the binder was observed throughout a major portion of the heating cycle and a molten surface was noted in some formulations prior to ignition. Ammonium perchlorate (AP) decomposition was studied in a high-pressure differential thermal analysis (DTA) apparatus and significant pressure effect on the decomposition rate was observed in the pressure range 15 to 215 psia. TAB

N66-37445# Polytechnic Inst. of Brooklyn, N. Y.

EXTENSIONAL MECHANICAL PROPERTIES OF POLYESTER AND POLYETHER BASED POLYURETHANES

Jerome M. Klosner, Alexander Segal, and Howard N. Franklin Jun. 1966 50 p refs
(Contract Nonr-839(32) FBM; Grant NSF GP-1246)
(PIBAL-922; AD-635788) CFSTI: HC $2.00/MF $0.50

An investigation of the extensional mechanical properties of a polyester based polyurethane and a polyether based polyurethane is described. Dynamic steady-state tests were performed over a frequency range of 1000 to 8000 cps and a temperature range of 50° to 110°F for the polyester material held at a constant elongation of 105%. The experiments on the polyether were conducted at 110% initial elongation over a range of frequency of 200 to 1600 cps, and a temperature range of 50° to 110°F. The complex modulus is found for both materials and the reduced variable concept applied. Master curves for the moduli are determined for a reference temperature of 510°R (50°F). Relaxation tests were performed on the same materials and the relaxation modulus determined. The relaxation spectrum is determined by using the data from the dynamic and relaxation experiments. Author (TAB)

N66-37680*# National Aeronautics and Space Administration Lewis Research Center, Cleveland, Ohio.
HIGH-ENERGY ION BEAMS USED TO ACCELERATE HYDROGEN PROPELLANT ALONG MAGNETIC TUBE OR FLUX
Gerald W. Englert Washington, NASA, Oct. 1966 51 p refs
(NASA-TN-D-3656) CFSTI: HC $2.00/MF $0.50 CSCL 18K

The energy transfer from a high intensity beam of lightweight ions to a hydrogen target bounded by a magnetic tube of flux was studied. The analysis was applied to the ion efflux from a hypothetical thermonuclear reactor. The ion stream escaping from the weaker mirror of a magnetic mirror system was represented by a high flux density monenergetic unidirectional beam. Energy transfer was most effective when the beam was concentrated on a dense closely confined target. Hydrogen ionization and acceleration was rapid near the station where the beam first impinged on the target. Beyond a one magnet diameter distance downstream from this station, velocity increased and density decreased to values that permitted little further energy transfer. The fractional ionization remained constant, but acceleration continued for two magnet diameters due to the magnetic field's high gradient that interacted with the remaining thermal energy in the propellant electrons. Little energy was transferred from beam to target at low hydrogen flow rates. At high flow rates, loss was mainly due to power consumed in ionizing the hydrogen. Hydrogen momentum was increased to seven times that of the beam with a 25% energy transfer efficiency. Author

N66-37804*# Jet Propulsion Lab., Calif. Inst. of Tech., Pasadena.
PROPELLANT EXPULSION IN UNMANNED SPACECRAFT
R. N. Porter and H. B. Stanford 1 Jul. 1966 76 p refs
(Contract NAS7-100)
(NASA-CR-78439; JPL-TR-32-899) CFSTI: HC $2.50/MF $0.75 CSCL 21H

Bladders, diaphragms, and pistons can be used for the positive expulsion of earth-storable liquid rocket propellants in free-fall (zero-g). Work on these devices since the 1940's provided a technological background that aided in the development of reliable bladders for use in Ranger and Mariner spacecraft. Current advanced development programs are aimed at providing expulsion technology for future spacecraft. Author

N66-37945*# Thiokol Chemical Corp., Elkton, Md.
[DEVELOPMENT OF A HYDROCARBON-TYPE OF POLYMER WHICH POSSESSES THE CHARACTERISTICS REQUIRED FOR USE AS A BINDER FOR UNCOATED SPO] First Quarterly Report, May 10–Aug. 10, 1966
C. W. Vriesen and C. R. Brenn 26 Aug. 1966 26 p refs
(Contract NAS7-478)
(NASA-CR-78450; E99-66) CFSTI: HC $2.00/MF $0.50 CSCL 07C

The best functionality of the carboxyl-terminated butadiene isoprene (BD/IP) copolymer was obtained when the removal of residual naphthalene was improved and when carbonation was accomplished by means of a jet tube. The use of a different source for butadiene and isoprene monomers has not resulted in increased functionality. A 1,3-butadiene-1,3-pentadiene copolymer has been hydrogenated to an iodine value of zero. Additional samples of the CT-BD/IP copolymer have been hydrogenated in the presence of palladium on barium sulfate catalyst. The aliphatic initiator DiLi-1 is being evaluated. Its use would eliminate the possible source of incompatibility introduced by the use of the aromatic hydrocarbon naphthalene. Initial experiments have been carried out on the copolymerization of 1,3-butadiene with 1,3-hexadiene and 2-(4-methylpentenyl-3) butadiene-1,3. These experiments are designed to provide improved fluidity. The synthesis of 1,3-dilithio-2 ethyl-2 butyl propane from the corresponding dibromo compound is being investigated in order to provide an aliphatic initiator which should be more soluble in aliphatic hydrocarbons because of the side chains. Author

N66-37993*# National Aeronautics and Space Administration. Marshall Space Flight Center, Huntsville, Ala.
CRYOGENIC TECHNOLOGY RESEARCH AT MSFC
1965 43 p *Its* Res. Achievements Rev. Ser. no. 3
(NASA-TM-X-53515) CFSTI: HC $2.00/MF $0.50 CSCL 21H

Cryogenic research related to fluid mechanics, propellant storage, and instrumentation in support of space vehicle programs is reviewed. It is noted that technology was inadequate during the principal design periods of the current vehicle programs; and that much work is needed in the study of propellant storage; cryogenic fluid behavior; integration of thermodynamics, propulsion, and structures; and advanced instrumentation and detection. Fluid mechanics programs deal with pressurization systems, rocket engine cooling, fluid geysering and dynamics; heat transfer, and explosive hazard. Insulation, shadow shields, cryogenic reliquefaction/refrigeration, and thermal integration are reported under propellant storage research. Instrumentation summaries are on a temperature sensor, fire detection and warning, a propellant mass device, and a fluid quality meter. M.W.R.

N66-38094# Koppers Co., Monroeville, Pa.
A CASE HISTORY OF THE DEVELOPMENT OF POLYSULFIDE POLYMERS
Edward M. Fettes *In* NAS-NRC Rept. of the *Ad Hoc* Comm. on Principles of Res.-Eng. Interaction Jul. 1966 16 p refs (See N66-38091 23-18) CFSTI: HC $7.00/MF $1.75

The history of the development of polysulfide polymers is reviewed, and attempts are made to analyze the factors pertinent to the progress of the development in terms of interactions between science and technology. Research-engineering interactions (REIs) are described, and a statistical analysis of the frequency of the more prominant REIs in the various phases of development is presented. The analysis is broken down into three sub-case histories: synthetic rubber, liquid polysulfide polymers as sealing compounds, and liquid polysulfide polymers as composite propellants. It is pointed out that the development of polysulfide polymers and the growth of the company producing them was due mainly to individual personalities, rather than to company attitude, structure, or support. L.E.W.

N66-38111# Joint Publications Research Service, Washington, D. C.
FLUORINE AND ITS COMPOUNDS AS ROCKET FUEL OXIDIZERS
29 Sep. 1966 24 p refs Transl. into ENGLISH from Vopr. Raketnoy Tekhn. (USSR), no. 7, 1965 p 28–41

High specific thrust, high rate of combustion, and high density are identified as the principal advantages of fuels with fluorine oxidizers, in this general discussion of the use of fluorine or fluorine compounds as oxidizers for solid or liquid propellants. The characteristic features of chlorine trifluoride, chlorine perfluoride, and bromine pentafluoride examined and the specific thrust of rocket fuels based on these oxidizers is given. Additionally, fluorine compounds containing nitrogen, oxygen, and carbon are assessed. It is concluded that certain fluorine compounds may be regarded as promising components of rocket fuels; however, the possibility of their use in liquid propellants is much greater than in solid propellants. H.S.W.

N66-38372# Air Force Systems Command, Wright-Patterson AFB, Ohio. Foreign Technology Div.
AN INTRODUCTION TO ROCKETRY

V. I. Feodos'yev and G. B. Sinyarev 15 Mar. 1966 579 p refs Transl. into ENGLISH of the Book "Vvedniye v Raketnuyu Tekhniku" Moscow, Oborongiz., 1960 p 1–506
(FTD-MT-64-236; TT-66-61924; AD-636616) CFSTI: HC $8.80/MF $2.50

Contents: Basic relationships in the theory of reaction propulsion; types of rocket vehicles and fundamentals of their construction; rocket engines, their construction and operational features; rocket engine propellants; processes in a rocket engine combustion chamber; flow of combustion products through the nozzle of a rocket engine; flight trajectory of ballistic rockets; basic principles of stabilization, control and guiding of rockets; forces and moments acting on a rocket in flight; ground equipment, rocket and rocket-engine tests. Author (TAB)

N66-38789*# Jet Propulsion Lab., Calif. Inst. of Tech., Pasadena.
DENSITY, VAPOR PRESSURE, AND VISCOSITY OF SOLUTIONS OF HYDRAZINE MONONITRATE IN HYDRAZINE
Stephen P. Vango and John B. Krasinsky 15 Oct. 1962 19 p ref
(Contract NAS7-100)
(NASA-CR-78593; JPL-TM-33-103) CFSTI: HC $1.00/MF $0.50 CSCL 07D

The density, vapor pressure, and viscosity are reported for two concentrations of hydrazine mononitrate dissolved in anhydrous hydrazine, and for these solutions with approximately 1% of added water. The preparation of the solutions and the techniques used to measure these values are described. Author

N66-38975*# Lockheed Missiles and Space Co., Sunnyvale, Calif.
THE LITERATURE OF LOW G PROPELLANT BEHAVIOR
G. A. Hastings, D. W. Hill, H. M. Satterlee, and J. G. Seebold 27 Sep. 1966 43 p refs
(Contract NAS9-5174)
(NASA-CR-65539; LMSC-A835805) CFSTI: HC $2.00/MF $0.50 CSCL 20D

Comments are made on 200 references to publications in the fields of low-g fluid mechanics and heat transfer which appeared during and after 1959. Major emphasis is given to the development of the theory of capillary fluid mechanics, and references which provide details regarding the results and history of development of this theory are identified. The publications selected in this bibliography are presented because of their practical importance to spacecraft designers, or because they were fundamental in the development of modern capillary fluid mechanics. The commentary is divided into seven sections dealing with propellant location and interface shape, interface stability, reorientation, sloshing, propellant containment and ullage control, draining, and heat transfer. Additional related topics are covered, and experimental techniques are discussed in the majority of the experimental investigations mentioned in the commentary. The bibliographic citations are grouped by calendar year, and listed alphabetically. H.S.W.

N66-39099# Atlantic Research Corp., Alexandria, Va. Kinetics and Combustion Group.
RESEARCH ON THE DEFLAGRATION OF HIGH-ENERGY SOLID OXIDIZERS Quarterly Technical Summary Report No. 2, Mar. 1–May 31, 1966
G. Von Elbe 30 Jun. 1966 24 p refs
(Contract AF 49(638)-1645)
(AFOSR-66-1758; AD-637562) CFSTI: HC $1.00/MF $0.50

Experimental work on the decomposition kinetics of ClO_2 was completed. The stable intermediate responsible for the delayed chain-branching explosion was established as a previously unknown chlorine oxide, Cl_2O_3. This new compound was synthesized and characterized and its role in ClO_2 explosions investigated. The explosive decomposition was studied from 65C to 134 C, and the effect of vessel size determined. A kinetic interpretation of the results is in progress Author (TAB)

N66-39139# Stanford Research Inst., Menlo Park, Calif.
THERMAL DIFFUSIVITY OF AMMONIUM PERCHLORATE
W. A. Rosser, S. H. Inami, and H. Wise [1964] 17 p refs Sponsored by ONR
(AD-614081) CFSTI: HC $1.00/MF $0.50

A method has been developed to measure the thermal diffusivity of poorly conductive materials. The method is absolute and rapid, and requires only small samples; tests of materials with known thermal properties confirm its accuracy. The thermal diffusivity of compressed NH_4ClO_4 powders has been measured as a function of porosity, particle size, and temperature. Author (TAB)

N66-39489# Utah Univ., Salt Lake City. Dept. of Chemical Engineering.
NON-ACOUSTIC COMBUSTION INSTABILITY OF SOLID PROPELLANTS
M. W. Beckstead 1 Aug. 1964 170 p refs Presented at the AIAA 3d Aerospace Sci. Meeting, New York, Jan. 1965
(Grant AF-AFOSR-466-63)
(AFOSR-66-1769; AD-637161) CFSTI: HC $5.00/MF $1.00

Non-acoustic combustion instability was examined in an uncatalyzed, a catalyzed, and two aluminized composite propellants. These propellants were studied, burning cigarette fashion, in a burner capable of operating at values of L* as small as 5 cm. It was observed that the frequency of the pressure oscillations varied with the value of L*, frequency decreasing with increasing L*. The data were correlated by plotting frequency versus the reciprocal of L*, yielding a series of constant pressure curves. This pressure effect was eliminated by using dimensionless variables, allowing all of the data for a given propellant to be correlated along the same line. A one-dimensional model is proposed that considers sinusoidal perturbations, allowing for growth of the disturbance. The pressure, the burning rate, the distributed temperature in the propellent, and the energy flux from the burning gases are the quantities perturbed. Author (TAB)

N66-39598# Dynamic Science Corp., Monrovia, Calif.
PROPELLANT SPRAYS IN LIQUID ROCKET ENGINES Final Report, 1 Apr. 1965–31 Mar. 1966
Melvin Gerstein 1 Jun. 1966 179 p refs
(Contract AF 49(638)-1552)
(SN-71; AFOSR-66-1671; AD-637236) CFSTI: HC $5.00/MF $1.00

The research described in this report is directed at obtaining an understanding of the behavior of propellant sprays in a liquid propellant rocket engine under oscillating flow conditions as a means of relating combustion stability to propellant properties and injector design. The report covers: (1) an outline of the work on the instability problem; (2) the combustion instability model; (3) calculation of fluctuations in the vaporization of liquid sprays for axisymmetric injection; (4) preliminary formulation of a transient problem associated with pressure oscillations in a rocket chamber; (5) calculation of Greens function for the transient instability problem; (6) a simple example of the calculation of the spray distribution function and the stability criterion; and (7) perturbation method for calculating stability boundaries. Sections 2 and 3 are related to treating a linear type instability where all oscillations are acoustic in nature. Sec 4 deals with the development of finite amplitude waves. In Sec. 5 a method of solution of the transient instability problem is discussed. Sections 6 and 7 cover a sample calculation of the spray distribution function and stability criterion. Significant results show that droplet vaporization can be a cause of combustion instability and that stability boundaries can be predicted from injector parameters and propellant properties Author (TAB)

N66-39618*# National Aeronautics and Space Administration. Lewis Research Center, Clevelend, Ohio.
ALTITUDE PERFORMANCE OF A TURBOJET ENGINE USING PENTABORANE FUEL
Joseph N. Sivo Washington, NASA, 20 May 1957 47 p refs
(NACA-RM-E57C20) CFSTI: HC $2.00/MF $0.50 CSCL 21E
(Declassified)

A full-scale turbojet engine having a two-stage turbine was operated with pentaborane fuel continuously for 11.5 minutes at a simulated altitude of 55,000 feet at a flight Mach number of 0.8. The engine incorporated an NACA combustor designed specifically for use with pentaborane fuel. The specific fuel consumption was initially reduced 32 percent below that obtained with gasoline fuel; however, the occurrence of a 25-percent reduction in net thrust after 8 minutes of operation resulted in a subsequent increase in specific fuel consumption to a value only 11.5 percent lower than that for gasoline. Author

N66-39623*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
ANALYSES FOR TURBOJET THRUST AUGMENTATION WITH FUEL-RICH AFTERBURNING OF HYDROGEN, DIBORANE, and HYDRAZINE
James F. Morris Washington, NASA, 18 Jun. 1957 26 p refs
(NACA-RM-E57D22) CFSTI: HC $2.00/MF $0.50 CSCL 21E
(Declassified)

Turbojet-engine net thrusts augmented with fuel-rich afterburning during takeoff and flight were computed. When compared at equal liquid weights, hydrogen, diborane, or hydrazine, burned at higher than stoichiometric fuel-air ratios, can produce thrusts that are, to some limit, greater than those for a 220-second specific-impulse rocket combined with stoichiometric afterburning of the turbojet fuel. At the conditions analyzed, this limit for liquid hydrogen is a liquid-air ratio of 0.16; the corresponding thrust is 27 percent greater than that for stoichiometric afterburning alone. Fuel-rich afterburning of 700°K hydrogen can yield augmented thrusts greater than those for stoichiometric combustion of 700°K hydrogen and 400°K air augmented with a 321.6-second specific-impulse rocket. Author

N66-39712*# Bureau of Mines, Pittsburgh, Pa.
SUMMARY OF LITERATURE SURVEY OF HYPERGOLIC IGNITION SPIKE PHENOMENA, PHASE I Final Report, Apr. 8–Dec. 31, 1965
Henry E. Perlee and Theodore Christos [1965] 48 p refs
(NASA Order T-39882(G))
(NASA-CR-78986) CFSTI: HC $2.00/MF $0.50 CSCL 21B

The results of the search of literature and industry are summarized. The problem is defined and the various physical and chemical processes occurring in the engine complex that would contribute to a hard start are discussed. The mechanics and scope of the industry survey and literature search are described. The physics of spray formation, chemistry of combustion, physicochemistry, and gas dynamics and transport are dealt with; information available in the literature on these subjects and the information gaps in each problem area are summarized. Author

N66-39930*# Thiokol Chemical Corp., Denville, N. J. Reaction Motors Div.
INVESTIGATIONS OF SPACE STORABLE PROPELLANTS (OF_2/B_2H_6) Final Report
H. Feigel 10 Jun. 1966 184 p refs
(Contract NAS3-2553)
(NASA-CR-5474; RMD-6039-F) CFSTI: HC $3.25/MF $1.00 CSCL 21I

Sea leval tests were made at the 2000-pound thrust level to check out hardware. Tests with propellant-cooled and heat sink type vortex injectors showed that OF_2/B_2H_6 can deliver high specific impulse. Allowing for nozzle divergence losses and combustion efficiency, 98% of theoretical vacuum shifting equilibrium specific impulse was obtained. Injector and combustion chamber heat transfer data were acquired. Altitude performance tests showed that OF_2/B_2H_6 delivers high specific impulse at $\geq$125,000 ft. A maximum specific impulse of 384 lb_f-sec/lb_m was obtained. Experimental data were compared with the theoretical shifting and frozen equilibrium and with the predicted kinetic performance. The specific heat of liquid OF_2 was experimentally determined over a range of temperatures and pressures typical of space operations. Reliability studies were made of thrust chamber concepts capable of extended firing over many cycles of operation with OF_2/B_2H_6. Promising advanced thrust chamber concepts were evaluated. Author

N67-10434# Library of Congress, Washington, D. C. Aerospace Technology Div.
SOLID PROPELLANT COMBUSTION Surveys of Foreign Scientific and Technical Literature, Jan. 1962–May 1966
Paul Vantoch and Seraphim Parandjuk 8 Aug. 1966 73 p refs
Anal. Surv.
(ATD-66-68)

This analytical survey contains a general discussion of selected articles on solid propellant combustion and comprises the abstracts of these articles. The information is divided into 8 sections: (1) The effect of pressure; (2) Particle size, porosity, and density; (3) The effect of temperature; (4) Condensed phase reactions; (5) Ignition characteristics; (6) Additives and catalytic effects; (7) Theoretical stability criteria; (8) Miscellaneous. The material reviewed indicates that Soviet investigators are placing emphasis on the following theee areas: the relationships between the pressure and the burning velocity; the effect of porosity, particle size, and density on burning velocity and instability; and condensed-phase reactions. Author

N67-10783*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
DESIGN OF COAST-PHASE PROPELLANT MANAGEMENT SYSTEM FOR TWO-BURN ATLAS–CENTAUR FLIGHT AC-8
William A. Groesbeck Washington, NASA, Nov. 1966 21 p refs
(NASA-TM-X-1318) CFSTI: HC $1.00/MF $0.50 CSCL 21I

The propellant management of a full-scale cryogenic storage to support restart of main engines, following an extended low-gravity coast period, was successfully demonstrated for the first time on the Atlas-centaur flight AC-8. Vehicle configuration and propellant management techniques conceived for this mission were verified as control of the residual propellants was maintained throughout a 25-minute orbital coast. Disturbances induced in the liquid residuals were suppressed, residual liquid kinetic energies were dissipated, tank pressurization was stable, boiloff gases were vented overboard in a nonpropulsive mode, and the propellants were retained in a settled position to support restart of the main engines. Definition of the AC-8 propellant management configuration resulted from experience on the AD-4 flight, the first full-scale coast-phase experiment with low-gravity propellant management.

This flight significantly revealed that model test results and scaling parameters did not properly account for the interaction between disturbing forces and energy levels peculiar to a full-scale configuration in a near earth orbit. The basic problems were those of controlling residual propellant motion and of discharging the boiloff gases overboard without upsetting the vehicle. The venting problem was corrected by redesigning the hydrogen vent system to inhibit liquid entrainment, to reduce impingement forces of vent gases against the vehicle, and to provide a more equal cancellation of the vent thrust forces. Author

N67-10793*# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, Calif.
BAFFLE THICKNESS EFFECTS IN FUEL SLOSHING EXPERIMENTS
Henry A. Cole, Jr. Washington, NASA, Nov 1966 14 p refs
(NASA-TN-D-3716) CFSTI: HC $1.00/MF $0.50 CSCL 20D

Measured damping forces on fuel sloshing baffles of varying thickness are presented from tests conducted with water in a two-dimensional tank and a cylindrical tank. The results show that baffle thickness decreases baffle effectiveness by as much as 50 percent at moderate amplitudes of oscillation. Ink-trace experiments conducted in the two-dimensional tank show baffle thickness effects on flow similarity. These results are used to show the mechanism by which baffle thickness affects damping. A table of critical thickness for flow similarity is given to serve as a guide to designers and experimenters. Author

N67-10895*# Rocketdyne, Canoga Park, Calif.
EVALUATION AND DEMONSTRATION OF THE USE OF CRYOGENIC PROPELLANTS (O_2-H_2) FOR REACTION CONTROL SYSTEMS Quarterly Report, 1 Apr.-1 Jul. 1966
N. Weber, N. Rodewald, E. Prono, G. Haroldsen, F. Hunter et al 13 Jul. 1966 82 p refs
(Contract NAS3-7941)
(NASA-CR-79704; R-6342-4; QR-4) CFSTI: HC $3.00/MF $0.75 CSCL 21H

In the thrustor design and fabrication effort, an analytical model was developed, incorporated in a computer program, and its operating characteristics determined. This simulation program was used to evaluate the pneumatic and thermal transient responses expected in the experimental hardware and flight-type design. The sensitivity of the operating characteristics to temperature and pressure perturbations was examined for various injector pressure drops, catalyst bed pressure drops, and feed pressure levels. Results show a $\pm$R temperature band, and a $\pm$0.5 psia pressure band as a probable operating limit. A subsystem analysis of the conditioner was undertaken, in which consideration was given to control system alternatives and the physics of the system for inclusion in a system simulation. Control system alternatives were based on the pressure deadband requirement determined in the thrustor effort. Detailed heat and material balances on the proposed experimental system were obtained, to serve as the design bases for the individual components. M.G.J.

N67-10900*# Whittaker Corp., San Diego, Calif. Narmco Research and Development Div.
DEVELOPMENT OF IMPROVED LOX COMPATIBLE LAMINATED GASKET COMPOSITE Final Summary Report, 16 Jun. 1965-16 Jun. 1966
Don Marano and William G. Sheck Aug. 1966 147 p refs
(Contract NAS8-5053)
(NASA-CR-79703) CFSTI: HC $4.00/MF $1.00 CSCL 11A

Various testing procedures, including load decay, compressive modulus, and leak, were made to develop a new cryogenic gasket compatible with liquid oxygen (LOX). These testing procedures were also employed to demonstrate shortcomings of existing cryogenic gaskets, including fiberglass-filled Teflon, encapsulated, and impregnated asbestos. Data are presented indicating that cold flow is the major problem of fluorocarbon polymers, which are frequently considered because of the LOX compatibility. Attempts were made to restrict the cold flow of the fluorocarbon materials by utilizing various fillers and encapsulated configurations. A glass fabric laminated structure was developed in which the glass fiber bundle was not completely saturated with fluorocarbon polymer binder. This permitted mechanical compressibility, not subject to drastic changes in compressive modulus when exposed to cryogenic temperatures. Some design criteria data are presented along with a theoretical analysis for predicting flange loads and internal pressure sealing capabilities. Various configurations utilizing the flat gasket concept are described, including O-rings, chevron seals, lip seals, ball seals, diaphragms, and flexible tubing. Process techniques are described for all configurations. Author

N67-11078# Air Force Systems Command, Wright-Patterson AFB, Ohio. Foreign Technology Div.
OXYGEN GASIFIER FOR PROLONGED MAINTENANCE OF LIQUID OXYGEN UNDER PRESSURE
G. I. Voronin and M. V. Zolotukhin 18 Apr. 1966 5 p
Transl. into ENGLISH from Russian Patent no. 168735 (Appl. no. 837399/23-26, 18 May 1963) 2 p
(FTD-TT-65-1740; AD-638882) CFSTI: HC $1.00/MF $0.50

The object of the invention is an oxygen gasifier for prolonged maintenance of the liquid oxygen under pressure, consisting of a thick-walled vessel with heat insulation, a system of gasification, and regulation of the pressure, to prevent over-heating the liquid oxygen at the walls of the vessel and its premature evaporation. The vessel has arranged inside of the inner cavity heat bridges with little thermal resistance. TAB

N67-11129# Naval Ordnance Test Station, China Lake, Calif.
LETTER REPORT OF PROGRESS ON WO 11, 294B DURING PERIOD 2 JANUARY-FEBRUARY 1966
M. W. Beckstead, J. E. Crump, G. L. Dehority, H. B. Mathes, Jr., E. W. Price et al 28 Feb. 1966 18 p
(NOTS-TN-5008-25)

Activity is reported in the areas of dynamic instability, acoustic losses, and steady state burning to aid in rocket motor design. Testing of an acoustic mode burner, propellants, spontaneous combustion oscillations, and instability in axial modes. In the field of steady state burning, photography of several propellants that experienced combustion instability is described and further interpretation of single crystal AP and sandwich deflagration tests is presented. S.P.

N67-11249# Stanford Research Inst., Menlo Park, Calif.
ELECTRICAL CONDUCTIVITY OF SOLID AMMONIUM PERCHLORATE Interim Report
Henry Wise 15 Sep. 1966 15 p refs
(Contract Nonr-3415(00))
(AD-639222) CFSTI: HC $1.00/MF $0.50

The electrical conductivity of solid ammonium perchlorate was measured over a temperature range from 500K to 600K. From the variation of the ionic conductivity in an applied electric field as a function of temperature, the enthalpy of formation of lattice defects is found to be 24 kcal and the energy barrier for lattice-defect migration, 20 kcal. The relatively high electrical conductivity of ammonium perchlorate compared with alkali halides and the marked influence of gaseous ammonia on the conductivity are interpreted in terms of a mechanism of charge transfer by proton jump Author (TAB)

N67-11331*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
MIXING AND REACTION STUDIES OF HYDRAZINE AND NITROGEN TETROXIDE USING PHOTOGRAPHIC AND SPECTRAL TECHNIQUES
Marshall C. Burrows Washington, NASA, 1966 15 p refs
Presented at the 5th Aerospace Sci. Meeting, New York, 23–25 Jan. 1967; Sponsored by AIAA
(NASA-TM-X-52244) CFSTI: HC $1.00/MF $0.50 CSCL 07B

Distances required to atomize, mix, and react N_2H_4 and N_2O_4 were experimentally determined for a quadlet injector element at 19 atmospheres and an oxidant-fuel weight ratio of 1.0. Streams of like propellants were diagonally opposite at an impingement angle of 90°. Silhouette photographs showed that atomization of the propellant streams occurred in less than 1 inch, and vaporizing pockets of NO_2 extended downstream for 4 inches or less. Concentration profiles of H_2O were determined from measured radiation and gas temperature and plotted as a function of axial distance. The resulting curves compared favorably with H_2O concentrations calculated for combustion profiles limited by either fuel or oxidant vaporization. Author

N67-11335*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
PARTICULATE DAMPING IN SOLID PROPELLANT COMBUSTION INSTABILITY
Louis A. Povinelli Washington, NASA, 1966 15 p refs Presented at the 5th Aerospace Sci. Meeting, New York, 23–25 Jan. 1967; sponsored by AIAA
(NASA-TM-X-52252) CFSTI: HC $1.00/MF $0.50 CSCL 21B

The effect of aluminum powder in damping solid propellant instability had been investigated in a vortex burner developed previously. The combustor was composed of a main chamber having a shallow center-perforated grain and a hot gas generator. The generator fed combustion gases tangentially into the main chamber causing transverse mode combustion instability. Aluminum powder was added either to the main propellant or to the gas generator charge. Measurement of the amplitude of the pressure oscillations indicated the effectiveness of the metal acting (a) as an ingredient at the solid surface and in the gas phase, and (b) in the gas phase only. In the absence of aluminum the combustor was unstable, exhibiting an oscillation frequency of 3800 cps with a peak-to-peak amplitude of 55 percent. The addition of fine aluminum powder to the propellant in the main chamber was sufficient to damp out the high-frequency instability. Addition of aluminum to the gas generator propellant only was also effective in eliminating instability provided that an equivalent concentration of metal particles was added. It was concluded that the addition of aluminum powder to solid propellants suppresses instability by acting as an attenuator of sound in the gas phase rather than altering the driving or response of the propellants. Author

N67-11397*# Boeing Co., Seattle, Wash. Aerospace Group.
CRYOGENIC STORAGE SYSTEM STUDY PROGRAM (AES PAYLOADS) Technical Final Report, Feb. 1–Aug. 1, 1966
Huntsville, Ala., NASA. Marshall Space Flight Center, 2 Nov. 1966 296 p refs
(Contract NAS8-20272)
(NASA-CR-61154) CFSTI: HC$3.75/MF$1.50 CSCL 22B

Extensive details are given on the development of LH_2 and LOX fuel storage systems for a lunar mission. Both active (vent gas cooled) and passive thermal protection systems were studied. Study ground rules and assumptions, initial investigations, preliminary design studies, development plan, and complete system test plans are covered. Some of the conclusions reached include: (1) Spherical tanks provide lower system weights than cylindrical tanks. (2) A single tank for containing a specific quantity of usable cryogen results in less storage system weight than mutiple tanks. (3) LH_2 storage system launch weights range from 3 to 4 times the weight of usable LH_2; however, launch weight of a LOX storage system is less than 1.2 times the weight of usable LOX. (4) A minimum-weight LH_2 storage system can be achieved only through increased complexity. (5) The use of fiberglass in tension rod supports provides a heat leak so low that benefits to be gained in using disengaging mechanisms appear nil. L.E.W.

N67-11398*# Boeing Co., Seattle, Wash. Aerospace Group.
CRYOGENIC STORAGE SYSTEM STUDY PROGRAM (AES PAYLOADS) Summary Technical Report, Feb. 1–Aug. 1, 1966
Huntsville, Ala., NASA. Marshall Space Flight Center, 2 Nov. 1966 56 p
(Contract NAS8-20272)
(NASA-CR-61155) CFSTI: HC$2.50/MF$0.50 CSCL 22B

The results of a design and analytical investigation undertaken to define LH_2 and LOX storage systems for a lunar mission are summarized. A simultaneous investigation was conducted on a wide variety of thermal protection systems and structural support design. Four storage systems (three for LH_2 and one for LOX) were selected for preliminary designs and detailed thermal analysis. The LH_2 storage systems were rated on payload weight and volume, confidence in achieving mission goals, and extent of development required. Development plans were developed that identified the tasks necessary to proceed toward the final design of LH_2 storage systems. L.E.W.

N67-11736*# General Dynamics/Convair, Huntsville, Ala.
ASSESSMENT OF SLOSH COUPLING WITH SPACE VEHICLE Final Report
L. L. Fontenot and M. O. Clark 24 Oct. 1966 83 p refs
(Contract NAS8-20302)
(NASA-CR-79541; GD/C-DDF-66-008) CFSTI: HC $3.00/MF $0.75 CSCL 20D

Results of an analytical study to determine the role of the action of the liquid in attitude stability equations of liquid propellant space vehicles are presented. The planar perturbation equations of motion for a liquid propellant launch vehicle have been formulated. The vehicle motion was treated as a summation of perturbations from a known reference motion and motion in which vehicle body axes remain coincident with reference axes. The effects of the liquid in the perturbation equations were isolated and identified. On replacing the liquid motion by a simple mechanical system, the planar perturbation equations of motion for the vehicle were again derived. The role of the liquid motions and mechanical motions were then compared; it was shown that the mechanical system did exactly duplicate the action of the liquid. The analysis was then extended to tanks of arbitrary shape having rotational symmetry. Again, the mechanical system was shown to duplicate the action of the liquid. However, the equation expressing the constancy of pressure at the free surface was found to contain an additional term proportional to the angular displacement of the body axes with respect to the reference axes. Author

N67-11812*# National Aeronautics and Space Administration. Marshall Space Flight Center, Huntsville, Ala.
A PRELIMINARY INVESTIGATION OF OXIDIZER-RICH OXYGEN-HYDROGEN COMBUSTION CHARACTERISTICS
Curtis R. Bailey Washington, NASA, Dec. 1966 30 p ref
(NASA-TN-D-3729) CFSTI: HC$2.00/MF$0.50 CSCL 21B

The operating characteristics of oxygen-hydrogen combustion were investigated over a propellant mixture ratio (O/F) band of 20 to 150. Firings were conducted in a 3600 pound thrust combustor at a chamber pressure of 1000 psia. Wedges fabricated from Inconel-X, Rene-41, and Waspalloy were placed in the exhaust of the combustor and subjected to the hot gases ranging in mixture ratio from 75 to 150. There were no significant heating problems with any of the combustor components. There was no erosion or melting of the test wedges except during a mixture ratio shift through stoichiometric in the start transient of one firing. Maximum characteristic velocity efficiencies of approximately 85 percent were achieved at propellant mixture ratios of 23 and 144. A minimum value of approximately 70% was observed at a mixture ratio of 70. Author

N67-12119*# Jet Propulsion Lab., Calif. Inst. of Tech., Pasadena.
APPLICATIONS TECHNOLOGY SATELLITE (ATS) MOTOR DEVELOPMENT
R. G. Anderson and R. A. Grippi *In its* Space Programs Sum. No. 37–40, Vol. IV 31 Aug. 1966 p 73–75 refs (See N67-12101 02-34) CFSTI: HC$3.75/MF$1.25

Results of storage and static firing are reported for the solid propellant apogee motor developed for the Applications Technology Satellite (ATS). After six months of storage, no detrimental effects were observed on the ATS storage units. Static firing is reported for the first combination apogee motor-spacecraft test; and temperature data from the externally mounted thermocouples and other data indicate that the apogee unit functioned nominally in all respects. Another static test shows that the mechanical portion of the safe and arm device can withstand the pressures of temperatures of a full duration apogee motor firing. M.W.R.

N67-12704*# Douglas Aircraft Co., Inc., Santa Monica, Calif.
WELD REPAIR OF LAUNCH VEHICLE FUEL AND LOX CONTAINERS
Eric Stone *In* Boeing Co. Saturn Mfg. Rev. [1966] p 15–16 (See N67-12701 03-15) CFSTI: HC$3.00/MF$0.75

The three main categories of weld repair methods currently used on the structural membrane of welded aluminum fuel and liquid oxygen containers for the Saturn S-IVB program include: (1) mechanized repair of the original weld in the same tooling and with the same equipment used for the original weld; (2) out-of-position mechanized repair of the original weld with specially developed tooling and equipment; and (3) out-of-position repair requiring redesign of the weld joint and replacement of the defective joint. For the first two categories, the necessary grind-out to remove the weld defect is simulated on a test panel. For the last type of repair, modification of the jamb fitting weld is used as an example; and full scale doublers, installed on 5-foot domes, were completely tested in a special test fixture prior to the rework of the production hardware. M.W.R.

N67-12760*# Martin Co., Denver, Colo.
CRYOGENIC LIQUID EXPERIMENTS IN ORBIT. VOLUME II: BUBBLE MECHANICS, BOILING HEAT TRANSFER, AND PROPELLANT TANK VENTING IN A ZERO-GRAVITY ENVIRONMENT
Jay L. Mc Grew and B. K. Larkin Washington, NASA, Dec. 1966 98 p refs
(Contract NAS8-11328)
(NASA-CR-652) CFSTI: HC$2.50/MF$0.75 CSCL 20M

The behavior of bubbles in a zero-gravity environment was investigated. Liquid flow around bubbles, which flow results strictly from surface tension gradients, was shown to cause an appreciable net force on the bubble. Theoretical prediction of the bubble force was made and was found to agree very well with experimental results. Temperature induced liquid flow around bubbles as a heat transport mechanism was also investigated. Liquid flow and temperature patterns were studied by use of various optical techniques. The growth and departure of boiling-produced vapor bubbles were studied. In addition phenomena of zero-gravity venting with boiling liquids were investigated. Freon and liquid hydrogen were used as test fluids in drop tower experiments. Author

N67-12972*# United Aircraft Corp., East Hartford, Conn.
ANALYTICAL STUDY OF CATALYTIC REACTORS FOR HYDRAZINE DECOMPOSITION Quarterly Progress Report, 15 Jul.–14 Oct. 1966
A. S. Kesten Oct. 1966 19 p refs
(Contract NAS7-458)
(NASA-CR-80336; E910461-6; QPR-2) CFSTI: HC $1.00/MF $0.50 CSCL 07A

A computer program representing the steady-state microscopic model of a distributed-feed catalytic reaction chamber was developed. This program provides for the simultaneous solution of the implicit integral equations describing reactant concentrations and temperature profiles in the porous catalyst particles, with the equations describing the variation of reactant concentrations and temperature with axial position in the interstitial phase. Test runs were made with the program as a whole and with the portion which treats simultaneous heat transfer, diffusion, and chemical reaction in the catalyst particles. A second program was written for the transient macroscopic model of a distributed-feed catalytic reaction chamber. Overall transport coefficients define the driving forces for heat and mass transfer in terms of the temperature and concentration differences between interstitial and gas phases in the interior of the catalyst particles. Differential equations for temperature and reactant concentrations were formulted and solved. K.W.

N67-13014*# Wyle Labs., Inc., Huntsville, Ala.
AIR BLAST PARAMETERS CLOSE TO A LIQUID PROPELLANT EXPLOSION
F. V. Bracco Jan. 1966 31 p refs Presented at the 2d Meeting of the Working Group on Hazard of the Interagency Chem. Rocket Propulsion Group, Sacramento, Calif. 7–9 Dec. 1965
(Contract NAS8-11217)
(NASA-CR-79733; WR-66-3) CFSTI: HC $2.00/MF $0.50 CSCL 20D

The proper system of equations is presented together with the logic of a numerical approach to solve them. To prove the practical importance of a rigorous approach, the magnitude of the near-field pressure is estimated and justified. For the rigorous solution, either the equation of state of the products of the explosion or the detonation velocity as a function of the loading density (or oxidizer to fuel ratio) must be known. The estimated solution has been based on the assumption that the initial air shock velocity is approximately equal to the detonation velocity and has also considered the influence of the explosive mass to energy ratio. The maximum energy release should be determined through an experimental approach. For the proper analysis of the close-field of liquid propellant explosions, it is concluded that the chemistry of the process should be included, that the proper set of equations is numerically solvable, that the shock transmission model should be improved, that the TNT equivalency system is physically incorrect, and that predicted blast pressures based on the use of the TNT equivalency system are overconservative. Author

N67-13161*# National Aeronautics and Space Administration. Marshall Space Flight Center, Huntsville, Ala.
PROPELLANT FEED DUCTING AND ENGINE GIMBAL LINES FOR THE SATURN VEHICLE
P. L. Muller, Jr. 4 Nov. 1966 49 p ref
(NASA-TM-X-53532) CFSTI: HC $2.00/MF $0.50 CSCL 21H

The propellant feed system concepts and configurations used on the Saturn V vehicle to convey propellants from the tank to the engine are described. In addition, the engine gimbal lines that provide flexibility for engine gimbaling and, therefore, vehicle control are described from the original concepts used on the Jupiter vehicle through the Saturn I to the more sophisticated systems of the Saturn V. Design and development of propellant feed systems for future vehicles will be based on the Saturn V feed system technology. Author

N67-13672*# Marquardt Corp., Van Nuys, Calif.
EXTRATERRESTRIAL RELIQUEFACTION OF CRYOGENIC PROPELLANTS Final Report, May 1964–Dec. 1965
L. A. Gibson, W. K. Wilkinson, and J. Tamusaitis 11 Dec. 1965 338 p refs
(Contract NAS8-5298)
(NASA-CR-80720; Rept.-6099) CFSTI: HC $7.00/MF $1.50 CSCL 21I

Reliquefier component design and cycles were investigated to study the feasibility of reducing or eliminating boil-off losses in extraterrestrial cryogenic propellant storage systems. Estimates were made of the mass and performance of reliquefiers for liquid hydrogen and liquid oxygen storage systems at lunar equatorial sites. The hydrogen-nitrogen dual pressure parallel cascade cycle and the Hampson cycle were found to be the most practical lunar hydrogen and oxygen reliquefier cycles, respectively. Component analyses and design studies were made of vertical and horizontal radiators; and finned tube, cross-counterflow tubular, and plate fin type heat exchangers. Diaphragm compressors and rotating machinery were also investigated. Radiator studies for earth orbit reliquefiers were conducted to establish the equivalent sink temperature as a function of altitude. Partial reliquefiers, externally powered and self-powered space power units, and expander-driving compressors were investigated for reducing cryogenic propellant boil-off losses. The feasibility of catalytic conversion for hydrogen reliquefaction was established. K.W.

N67-13674*# Union Carbide Corp., Bound Brook, N. J. Polymer Research and Development Dept.
SATURATED HYDROCARBON POLYMERIC BINDER FOR ADVANCED SOLID PROPELLANT AND HYBRID SOLID GRAIN Quarterly Report, 1 Aug.–31 Oct. 1966
J. E. Potts ed. 31 Oct. 1966 17 p ref Prepared for JPL
(Contracts NAS7-100; JPL-951210)
(NASA-CR-80718; QR-4) CFSTI: HC $1.00/MF $0.50 CSCL 21I

Factors which might adversely influence the attainment of satisfactory levels of carboxyl content in the prepolymer were examined. The choice of solvent in the molecular weight determination had previously been found to be very critical. The titrimetric procedure for determining neutralization equivalent was found to be lacking in accuracy and was altered. The possibility that polymeric anhydrides were being formed during sample work-up was tested; no evidence for the presence of anhydrides was found. The monomer neohexene was analyzed for chain transfer impurities; none were found. The oxygen functionality of the prepolymer made with DMAB initiator was found to decrease with increasing batch reaction time, indicating a changing reaction environment. Further examination of these products demonstrated concentration of carboxyl groups, which was not compatible with the copolymer. Author

N67-13680*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
EXPERIMENTAL INVESTIGATION OF LIQUID-PROPELLANT REORIENTATION
Jack A. Salzman and William J. Masica Washington, NASA, Jan. 1967 22 p refs
(NASA-TN-D-3789) CFSTI: HC $1.00/MF $0.50 CSCL 20D

As a part of study of liquid propellants stored in space-vehicle tanks while exposed to weightlessness, the mechanism of liquid reorientation from an initially highly curved interface by low-level accelerations was examined. Used were several propellant tank models with radii ranging from 1.27 to 5.16 centimeters and liquids possessing near 0° contact angles on the tank materials and having viscosities of the order of unity. The results indicate that, while liquid rebounding or geysering will occur in most practical reorientation maneuvers, there exists a distinct region in which geysering will not occur. A criterion consisting essentially of a dimensionless Weber number grouping successfully delineated the regions of geysering and no geysering within experimental limitations. Quantitative results of liquid accumulation rates that would allow time estimates for complete liquid reorientation are heavily dependent on overall geyser dynamics. Author

N67-14266# Entwicklungspring Nord, Bremen (West Germany).
ELDO FUTURE PROGRAM STUDY 3.2 ON AN ELDO B LAUNCHING SYSTEM WITH A STANDARD ENGINE OF 6–8 TONS OF THRUST
31 Aug. 1964 62 p refs Prepared for ELDO
CFSTI: HC $2.00/MF $0.75

An investigation was conducted on the influence which the selections of a standard engine with 6 to 8 tons of thrust exerts on the performance of an ELDO B launch vehicle with two H_2/O_2 upper stages totalling 23 tons upper stage weight, including propellants and payload. Included are calculations for an ELDO B2-stage launch vehicle with a view to use of its upper stages in an ELDO C vehicle. ESRO

N67-14275# Bolkow Entwicklungen K. G., Munich (West Germany).
DESIGN AND DEVELOPMENT PROPOSAL FOR A ROCKET ENGINE WITH 6 TONS THRUST: ELDO STANDARD PROPULSION UNIT FOR HIGH ENERGY UPPER STAGES
Oct. 1964 37 p refs Prepared for ELDO
(TR-542) CFSTI: HC $2.00/MF $0.50

A proposal for design of a hydrox, rocket engine of thrust 6 ton for use as high energy upper stage of ELDO B or C launch vehicles is presented. The engine has conventional turbopump feed system and arrangement, medium chamber pressure, conventional nozzle, constant thrust level, constant propellant mixture ratio, restart capability in space and minimum specific impulse of 425 sec. ESRO

N67-14278# Applicazioi e Ricerche Scientifiche, Milan (Italy).
ELDO FUTURE PROGRAMME PRELIMINARY STUDY NO. 3-1. PART I: HIGH-ENERGY PROPELLANTS PROPERTIES AND PERFORMANCES
Jul. 1965 148 p refs
(ARSN-6) CFSTI: HC $4.00/MF $1.00

This report presents data on the propellant properties and characteristics which influence the design, operation and performance of a liquid rocket propulsion system. It considers a number (30) of high energy propellants and a number (88) of possible fuel oxidizer combinations of these propellants which should yield a minimum specific impulse of 300 sec. at sea level. ESRO

N67-14292# Bolkow Entwicklungen K. G., Munich (West Germany).
ELDO FUTURE PROGRAM STUDY 3.7: PERFORMANCE ANALYSIS ELDO B1 LAUNCH VEHICLE
Aug. 1965 86 p Prepared for ELDO
(BOLKOW-RF-34) CFSTI: HC $3.00/MF $0.75

Studies optimum propellant mass for second stage of the ELDO B1 vehicle for launches from Woomera or an equatorial site. Four types of orbit are considered: 1) low circular orbits with direct injection, 2) high circular orbits with Hohmann transfer from a parking orbit, 3) elliptical orbits with fixed perigee (including high circular orbits reached by an apogee motor) and 4) escape missions. Trajectories are calculated for four or five representative orbital altitudes between 200 and 100,000 km. ESRO

N67-14305# Office National d'Etudes et de Recherches Aeronautiques, Paris (France).

RECENT RESULTS OBTAINED WITH HYBRID SYSTEMS OF LITHERGOLS [RESULTATS RECENTS OBTENUS SUR LES SYSTEMES HYBRIDES OU A LITHERGOLS]

Marcel Barrere and Andre Moutet [1966] 30 p refs In FRENCH Presented at the 17th Intern. Astronautical Congr., Madrid, 9–15 Oct. 1966 Submitted for Publication

(TP-395) CFSTI: HC$2.00/MF$0.50

Following a brief survey of previous results, the trends concerning the choice of the propellants are indicated. The various phases in the ignition are described and the methods used for the ignition of nonhypergolic or slightly hypergolic propellants are analyzed. The laws giving the regression rate, and obtained from laboratory apparatus or from actual engine runs, are discussed. The combustion modes in engines are described and three possible combustion models are presented. The combustion must be organized so that the regression rate is sufficient and the mixing of the propellants is as efficient as possible. There are low frequency instabilities for some operating conditions. Although thrust modulation is possible, it is difficult to obtain when a constant mixing ratio is desired during the modulation. Author (ESRO)

N67-14308# Bolkow Entwicklungen, K. G., Munich (West Germany).

ELDO FUTUR PROGRAM PRELIMINARY STUDY NO. 3-1 PRELIMINARY STUDY ON THE USE OF HIGH-ENERGY PROPELLANTS AND DEFINITION OF AN ELDO-B LAUNCH VEHICLE PART I

Apr. 1964 138 p refs Work performed for Eldo

(Bolkow-RF-13) CFSTI: HC$4.00/MF$1.00

This paper reviews the state of the art of high energy propellants, assesses and compares their performance and considers their possible application. The propellants considered are combinations of the fuels liquid hydrogen or hydrazine with oxidizers liquid oxygen, liquid fluorine, oxygen/fluorine or oxygen bifluoride having specific impulse greater than 400 sec. It also discusses briefly use of metal additives with propellants. ESRO

IAA ENTRIES

A66-17099 #

BUBBLE BEHAVIOR IN LIQUIDS CONTAINED IN VERTICALLY VIBRATED TANKS.

Daniel D. Kana and Franklin T. Dodge (Southwest Research Institute, Dept. of Mechanical Sciences, San Antonio, Tex.).

American Institute of Aeronautics and Astronautics, Aerospace Sciences Meeting, 3rd, New York, N.Y., Jan. 24-26, 1966, Paper 66-86. 16 p. 11 refs.

Members, $0.50; nonmembers, $1.00.

Contract No. NAS 8-11045.

Violent bubble motions observed in liquids contained in a vertically vibrating tank are analyzed both theoretically and experimentally. The behavior is characterized by sinking bubbles and large bubble clusters that collect at various levels in the tank. A fluid pressure resonance, which occurs at a frequency well below the resonant frequency of a pure liquid column, is also observed. The most violent part of the behavior appears to be a result of a water hammer type of resonance in a bubbly liquid-air mixture contained in an elastic tank. The proposed theory explains the entire behavior quite satisfactorily, at least for the test conditions. It is believed that motions of this type may occur in rocket propellant tanks during periods of intense longitudinal vibration. (Author)

A66-17101 #

IGNITION OF AMMONIUM PERCHLORATE COMPOSITE PROPELLANTS BY CONVECTIVE HEATING.

J. A. Keller, A. D. Baer, and N. W. Ryan (Utah, University, Dept. of Chemical Engineering, Salt Lake City, Utah).

American Institute of Aeronautics and Astronautics, Aerospace Sciences Meeting, 3rd, New York, N.Y., Jan. 24-26, 1966, Paper 66-65. 16 p. 19 refs.

Members, $0.50; nonmembers, $1.00.

Grants No. AF AFOSR 40-63; No. AF AFOSR 40-64.

A comprehensive experimental study was made of the ignition of ammonium perchlorate propellants in a shock-tube apparatus. Test variables were: (1) heat flux, (2) test-gas temperature, (3) test-gas velocity, and (4) pressure. Convective heat fluxes at the propellant surface were varied over the range of about 20 to 160 cal/(cm)^2(sec). Compositional factors studied were (1) particle size of ammonium perchlorate, (2) catalysts, and (3) fuels. The experimental results showed that, in the range of conditions used, ignition characteristics of ammonium perchlorate propellants are in agreement with those predicted by thermal ignition theory. However, for propellant samples with surface irregularities, the thermal ignition process is accelerated at low test-gas velocities by external-flux-augmenting exothermic reactions among decomposition products at the surface. These decomposition products are produced at local hot spots resulting from two-dimensional convective heating of protrusions. The experimental data indicate that the key reaction in the ignition process is the low-temperature thermal decomposition of ammonium perchlorate. (Author)

A66-17105 #

NON-ACOUSTIC INSTABILITY OF COMPOSITE PROPELLANT COMBUSTION.

M. W. Beckstead (U.S. Naval Ordnance Test Station, China Lake, Calif.), N. W. Ryan, and A. D. Baer (Utah, University, Salt Lake City, Utah).

American Institute of Aeronautics and Astronautics, Aerospace Sciences Meeting, 3rd, New York, N.Y., Jan. 24-26, 1966, Paper 66-111. 16 p. 20 refs.

Members, $0.50; nonmembers, $1.00.

Grant No. AF AFOSR 446-63.

The nonacoustic combustion instability of an aluminized composite propellant has been examined. The propellant was studied in an end burner capable of operating at values of L* as small as 5 cm. It was observed that the frequency of the pressure oscillations varied with L*, pressure being a parameter. The pressure effect was eliminated by using dimensionless variables suggested by a mathematical analysis. A one-dimensional model is proposed that considers sinusoidal perturbations, allowing for exponential growth of the disturbance. The analysis is developed utilizing an energy balance for the burning solid propellant that accounts for energy accumulation in the solid and a mass balance on the rocket chamber that considers mass accumulation in the gas chamber. The analysis reduces to an expression relating the reciprocal of the dimensionless frequency in terms of a growth constant and propellant parameters. The results of this investigation can be considered significant in two respects: first, an experimental L*-frequency dependency was observed in nonacoustic instability, and was correlated through the use of a dimensionless frequency and L*; secondly, a mathematical expression has been derived that agrees qualitatively with the observed, experimental results, subject to the given assumptions. (Author)

A66-17463

DISSOCIATION ENERGY OF THE N-H BOND IN HYDRAZINE.

I. P. Fisher and G. A. Heath (Ministry of Aviation, Rocket Propulsion Establishment, Westcott, Bucks., England).

Nature, vol. 208, Dec. 18, 1965, p. 1199, 1200. 10 refs.

Investigation of the discrepancy between the measured value of the dissociation energy of the N - H bond in hydrazine and that indicated by other chemical evidence. Experiments showed it to be possible to obtain parallel ionization efficiency curves for hydrazine and the calibrating gas only after the hydrazine had been in the mass spectrometer for several hours. F.R.L.

A66-18028

TOWARD A UNIFIED COMBUSTION THEORY.

R. H. Essenhigh (Pennsylvania State University, Combustion Laboratory, University Park, Pa.) and J. B. Howard (Pennsylvania State University, University Park, Pa.).

I & EC - Industrial and Engineering Chemistry, vol. 58, Jan. 1966, p. 14-23. 73 refs.

Review of the concepts and data contained in the literature on the combustion of pyrolyzing solids. The intent of the review was to determine what material is applicable to combustion in hybrid propulsion devices. Inasmuch as most of the relevant past research has pertained to coal, special emphasis is placed on this fuel. It is shown that based upon experimental results with fine particles of less than 100 μ in size, significant devolatilization starts only after ignition. The history and literature of research on the combustion of pulverized coal is discussed. Prevailing views on pyrolysis and combustion mechanisms are described; it has been established that small particles of less than 100 microns are not diffusion controlled, and the threshold rate theory of diffusion has been repudiated. D. P. F.

A66-18452 #

AN EXPERIMENTAL STUDY OF HYPERGOLIC IGNITION AND RESTART IN A UNIQUE HYBRID WINDOW MOTOR.

J. W. Connaughton, B. F. Wilson, and W. W. Wharton (U.S. Army, Missile Command, Redstone Arsenal, Ala.).

American Institute of Aeronautics and Astronautics, Aerospace Sciences Meeting, 3rd, New York, N.Y., Jan. 24-26, 1966, Paper 66-69. 15 p. 5 refs.

Members, $0.50; nonmembers, $1.00.

High-speed photography and measured motor parameters were used to determine ignition delays in a three-dimensional, solid fuel chlorine trifluoride, hybrid system. A 6-in. ID chamber, incorporating a 2- by 9-in. full length Plexiglas window, contained the 1/2-in.-web half-cylindrical grain. Injector elements were contained in only half of the injector adjacent to the grain. A low regression rate fuel, polybutadiene-acrylic acid copolymer (PBAA) rubber, and a high regression rate fuel containing butyl rubber binder were used. The total ignition delay was defined as the time from first indication of injection pressure to initial peak chamber pressure. The major factors found to affect ignition delay were: oxidizer flow transient, injector spray characteristics, chemical reaction rates, flame propagation rate, and chamber pressurization rate. Total ignition delays of between 75 and 630 msec were obtained during the study, and the duration of identifiable phases of ignition were measured. The ignition delay is shortened or lengthened as changes in parameter values influence these phases. This study emphasizes the interrelationship of components and motor geometry to the rates of heterogeneous ignition reactions. (Author)

A66-18460 #
STRESS ANALYSIS OF PHYSICALLY NONLINEAR SOLID PROPELLANTS.
Karl S. Pister (California, University, Dept. of Civil Engineering, Berkeley, Calif.) and Roger J. Evans (Columbia University, Dept. of Civil Engineering, New York, N.Y.).
American Institute of Aeronautics and Astronautics, Aerospace Sciences Meeting, 3rd, New York, N.Y., Jan. 24-26, 1966, Paper 66-124. 12 p. 12 refs.
Members, $0.50; nonmembers, $1.00.
Army-Navy-supported research.

Discussion of a mechanical constitutive theory and a method of stress analysis applicable to elastic materials for which physical nonlinearity is postulated to be more important than kinematic nonlinearity. The theory and stress analysis technique are applied to two axisymmetric plane strain problems which relate to the stress analysis of solid propellant grains. A constitutive equation is developed for an isotropic, homogeneous medium. Some homogeneous states of deformation are considered with particular reference to the characterization of material properties. Alternate methods of solution for the differential equations of equilibrium for axisymmetric plane strain are given and compared. D. P. F.

A66-18573
DEVELOPMENT PROBLEMS OF SOLID CHEMICAL PROPULSION ROCKET ENGINES.
David F. Sprenger (Aerojet-General Corp., Sacramento, Calif.).
(Conference on Civilian and Military Uses of Aerospace, New York, N.Y., Jan. 11-14, 1965, Paper.)
New York Academy of Sciences, Annals, vol. 134, Nov. 22, 1965, p. 289-303.

Discussion of design considerations for solid propellant rockets. Attempts to develop stop-restart and variable-thrust solid-propellant engines are reviewed. The materials considerations for these modes of engine operation are examined. Work on propellant structural characteristics is described, together with work on nozzles and nozzle-cooling techniques. Studies of shock-free and shock-augmented thrust-vector control systems are discussed. P.K.

A66-18723 #
LINEAR VELOCITY OF PYROLYSIS OF AMMONIUM PERCHLORATE IN ONE-DIMENSIONAL FLOW [VITESSE LINEAIRE DE PYROLYSE DU PERCHLORATE D'AMMONIUM EN ECOULEMENT UNIDIMENSIONNEL].
Maurice Guinet.
La Recherche Aérospatiale, Nov.-Dec. 1965, p. 41-49. 11 refs.
In French.

Description of a device to measure linear pyrolysis velocity in terms of its thermodynamic parameters which is applied to the determination of the pyrolysis velocity of ammonium perchlorate between 350 and 700°C at pressures between 1 and 26 atm. Data concerning the pyrolysis velocity are applicable to numerous problems such as the combustion of solid heterogeneous propellants and ablative effects. The substance to be tested is heated by a high-current-density, low-voltage transformer in an inert atmosphere within a steel housing equipped with an observation port. The results of experimental measurements of the velocity of ammonium perchlorate pyrolysis are represented in the form of curves. It is shown that there are two pyrolytic domains - the first involving a process of pure pyrolysis and the second relating to the superposition of surface and exothermal reactions. D. P. F.

A66-18809 #
AN ANALYSIS ON PREDICTING THERMAL STRATIFICATION IN LIQUID HYDROGEN.
J. H. Robbins and A. C. Rogers, Jr. (North American Aviation, Inc., Space and Information Systems Div., Downey, Calif.).
(American Institute of Aeronautics and Astronautics, Annual Meeting, 1st, Washington, D.C., June 29-July 2, 1964, Paper 64-426.)
Journal of Spacecraft and Rockets, vol. 3, Jan. 1966, p. 40-45. 7 refs.

A66-18825 #
A STUDY OF COMPOSITE SOLID PROPELLANTS CONTAINING IRRADIATED AMMONIUM PERCHLORATE.
J. E. Flanagan and J. C. Gray (North American Aviation, Inc., Rocketdyne Div., Research Dept., Solid Propulsion Section, Canoga Park, Calif.).
Journal of Spacecraft and Rockets, vol. 3, Jan. 1966, p. 135.

Description of an attempt to separate binder-oxidizer interactions by formulating and firing composite solid propellants containing preirradiated ammonium perchlorate (AP). Burning rates increased, and the pressure exponent increased for polybutadiene propellants, but the exponent decreased in a polysulfide formulation. Heats of explosion were reduced in propellants containing the irradiated oxidizer. R.A.F.

A66-18949 #
FLAME SPREADING OVER THE SURFACE OF IGNITING SOLID ROCKET PROPELLANTS AND PROPELLANT INGREDIENTS.
Robert F. McAlevy, III, Richard S. Magee, John A. Wrubel, and Fred A. Horowitz (Stevens Institute of Technology, Combustion Laboratory, Hoboken, N.J.).
American Institute of Aeronautics and Astronautics, Aerospace Sciences Meeting, 3rd, New York, N.Y., Jan. 24-26, 1966, Paper 66-68. 16 p. 21 refs.
Members, $0.50; nonmembers, $1.00.
Grant No. NGR-31-003-014.

The velocity at which flame spreads over the surface of igniting nitrate ester propellants, ammonium perchlorate and thermoplastics has been measured as a function of pressure level and chemical nature of the surrounding, quiescent atmosphere as well as specimen surface condition. Small test specimens, mounted horizontally, prepared surface upward, in a relatively large test chamber were ignited and the flame spreading velocity obtained cinematographically Flame spreading velocity was found to vary: directly with pressure level (between 0.1 and 1.0 atmospheres); directly with oxygen fraction of environments composed of oxygen-nitrogen mixtures; and inversely with specimen surface smoothness. For rough-surfaced specimens photographic evidence of random ignition sites ahead of the spreading flame has been obtained, presumably a result of increased radiant heating. A gas phase theory of flame spreading is presented; flame spreading is viewed as a continuous gas phase ignition process. For smooth-surfaced specimens, an analytical prediction of flame spreading velocity is supported by the data obtained. (Author)

A66-19153 #
FINITE RATE EVAPORATION OF HYDROGEN IN AIR.
Raymond Edelman and Harold Rosenbaum (General Applied Science Laboratories, Inc., Westbury, N.Y.).
(American Institute of Aeronautics and Astronautics, Aerospace Sciences Meeting, 2nd, New York, N.Y., Jan. 25-27, 1965, Paper 65-7.)
AIAA Journal, vol. 4, Jan. 1966, p. 163-165. 6 refs.
NASA-supported research.

A66-19163 #
GAS EVOLUTION FROM A SOLID ROCKET PROPELLANT DURING DEPRESSURIZATION TO PRODUCE A QUENCH.

Edward A. Fletcher and Gene W. Bunde (Minnesota, University, Dept. of Mechanical Engineering, Combustion Laboratory, Minneapolis, Minn.).
(American Institute of Aeronautics and Astronautics, Aerospace Sciences Meeting, 2nd, New York, N.Y., Jan. 25-27, 1965, Paper 65-104.)
AIAA Journal, vol. 4, Jan. 1966, p. 181, 182.
Contract No. NAS3-2554.

A66-19428 #
ANALYTICAL DEPENDENCE OF LIQUID OXYGEN DENSITY ON TEMPERATURE AND PRESSURE [ANALITICHESKAIA ZAVISIMOST' PLOTNOSTI ZHIDKOGO KISLORODA OT TEMPERATURY I DAVLENIIA].
V. N. Novotel'nov and L. A. Akulov (Tekhnologicheskii Institut Kholodil'noi Promyshlennosti, Leningrad, USSR).
Inzhenerno-Fizicheskii Zhurnal, vol. 9, Dec. 1965, p. 802, 803. In Russian.

Brief note on a simple empirical expression of oxygen density as a function of temperature and pressure. The expression is set up on the basis of experimental results for temperatures from 153 to 83°K and pressures of (78.5 to 196) x 10^5 newtons/m^2. V.Z.

A66-19697
CONTINUOUS MEASUREMENT OF SOLID PROPELLANT BURNING RATES.
J. R. Osborn, R. J. Burick, and R. F. Panella (Purdue University, School of Mechanical Engineering, Lafayette, Ind.).
Review of Scientific Instruments, vol. 37, Jan. 1966, p. 86-92. 6 refs.
Grant No. AF-AFOSR 207-63.

An experimental system is presented for the direct and continuous measurement of the burning rates of solid rocket propellants under conditions closely approximating those of a solid rocket motor. The system involves a positioning type servomechanism which moves a sample of solid propellant within a two-dimensional rocket motor such that the receding burning surface of the sample is maintained at a fixed position with respect to the motor. Since the burning surface remains fixed, the direct measurement of the velocity of the propellant feed mechanism for adjusting the position of the propellant sample yields the burning rate. The servomechanism incorporated a 50-mcurie ^{137}Cs source of gamma rays coupled with a scintillation probe for detecting the position of the burning propellant surface. The output of the probe was converted into a voltage by a ratemeter. It was then amplified and compared to a standard voltage which was proportional to a desired propellant surface position. The resulting difference was amplified for the purpose of driving a 0.6-hp servomotor which positioned the burning surface of the propellant sample The size of the sample was approximately 2.5 cm square by 10 cm long. The experimental data were obtained with the above servomechanism for two composite propellant formulations. The data were obtained for a range of pressures from 8.8 to 35.5 kg/cm^2, and for burning rates ranging from 0.40 to 0.8 cm/sec. The data correlated well with previously published data. A theoretical analysis of the servomechanism was performed to determine system stability and performance. An optimization analysis of the servomechanism system yielded optimum operating parameters. (Author)

A66-19728 #
THEORY OF IGNITION OF SOLID PROPELLANTS.
E. W. Price, H. H. Bradley, Jr., G. L. Dehority, and M. M. Ibiricu (U.S. Naval Ordnance Test Station, China Lake, Calif.).
American Institute of Aeronautics and Astronautics, Aerospace Sciences Meeting, 3rd, New York, N.Y., Jan. 24-26, 1966, Paper 66-64. 102 p. 55 refs.
Members, $0.50; nonmembers, $1.00.

Surface ignition of solid propellants has been represented by several analytical models, each involving obvious compromises with regard to scope of applicability. These models are distinguishable primarily in terms of site of the exothermic reaction governing ignition. Early research with nitrocellulose led to development of a theory involving chemical heat generation in the condensed phase. Two subsequent theoretical models were developed to explain ignition of the solid fuel ingredient of a composite propellant in an oxidizing atmosphere, and these two models were then extended on a heuristic basis to encompass a composite propellant in an inert atmosphere in which the oxidizing gas was produced by decomposition of the solid oxidizer. These two models are distinguished by whether the oxidation occurs at the surface or in the gas film above the surface. This paper reviews the solid, heterogeneous, and gas-phase ignition theories and reviews the nature and implications of the assumptions involved. It is concluded that, while possessing certain drastic simplifications in common, the various quantitative models differ so conspicuously in their assumptions regarding external initiating stimulus as to make quantitative comparisons or tests of validity impossible. (Author)

A66-19754 #
SELECTED CHAPTER ON THE CHEMISTRY OF ROCKET PROPELLANTS. VII - PROPELLANT COMPONENTS AND INTERMEDIATE PRODUCTS [EIN AUSGEWÄHLTES KAPITEL AUS DER CHEMIE DER RAKETENTREIBSTOFFE. VII - TREIBSTOFFKOMPONENTEN UND ZWISCHENPRODUKTE].
Ernst-Eberhard Büchner.
(Regionaltagung für Raketentechnik und Weltraumforschung, Kiel, West Germany, 1965, Paper.)
Hermann Oberth-Gesellschaft, Mitteilungen, vol. 2, Nov.-Dec. 1965, p. 165-167. 11 refs. In German.

Description of the properties, applications, and method of preparing the following propellants for rocket engines -- Centralit I, II, and III, diamylphthalate, dibutylphthalate, dicotylphthalate, diglycol dinitrate, m-dinitrobenzene, dinitrochlorbenzene, dinitrotoluene, guanidine nitrate, and nitroguanidine. Centralit I, II, and III are used as stabilizing agents. The three phthalic acid derivatives are gelatinizing agents. Dinitrobenzene is prepared by the direct nitration of benzene with nitric acid. Dinitrochlorbenzene is an intermediate product used in the synthesis of certain propellants such as trinitroaniline. Dinitrotoluene is an intermediate in the preparation of the trinitro compound. The guanidine compounds find applications because of their gas generating properties. D.P.F.

A66-19954
CONTAMINATION CONTROL IN MISSILE SYSTEMS.
Paul S. Gakle (Aerojet-General Corp., Sacramento, Calif.).
Materials Protection, vol. 5, Jan. 1966, p. 65-67.

Consideration of rocket engine cleanliness as a quality control parameter. Two propellant systems are discussed: the LOX and kerosene system, and the nitrogen tetroxide/Aerozine-50 (Aerojet-General Corp.) system. A contaminant is defined as any material that is located in an area foreign to its intended use which may interfere with the safe and reliable operation of the rocket engine. Methods of detection, sources of contamination, methods of prevention, and chemical corrosion are discussed. Six conclusions are drawn: (1) cleanliness is a major contributor to missile reliability; (2) successful contamination control requires well-trained and alert personnel as well as planning and adequate facilities; (3) no method can predict what level of cleanliness will be required for a given system; (4) contamination limits can be extrapolated from one program to another, especially when the same propellants are used; (5) N_2O_4, RP-1, and Aerozine-50 systems are less sensitive to contamination than is LOX; and (6) high cleanliness levels provide additional benefits in low rejection rates and fewer accidents. M.L.

A66-20576 #
CONTROLLED INTERRUPTION OF COMBUSTION IN A SOLID-PROPELLANT ENGINE [INTERRUZIONE COMANDATA DELLA COMBUSTIONE IN UN MOTORE A PROPELLENTE SOLIDO].
Giannetto Corsi and Tommaso Moreschini (Bombrini Parodi-Delfino S.p.A., Rome, Italy).
Missili e Spazio, vol. 7, Apr. 1965, p. 61-66. In Italian.

Description of a process for arresting combustion in solid-propellant engines. The possibilities of application of the process to rockets and missiles are discussed. M.M.

A66-20801

THERMODYNAMIC FUNDAMENTALS FOR THE INCREASE IN PERFORMANCE OF CHEMICAL LIQUID AND SOLID ROCKET ENGINES WITH SPECIAL EMPHASIS ON THE PROPERTIES OF THE PROPELLANT [THERMODYNAMISCHE GRUNDLAGEN DER LEISTUNGSSTEIGERUNG VON CHEMISCHEN FLÜSSIGKEITS- UND FESTSTOFFRAKETENTRIEBWERKEN UNTER BESONDERER BERÜCKSICHTIGUNG DER TREIBSTOFFEIGENSCHAFTEN].
Otfried Stumpf.
Forschung im Ingenieurwesen, vol. 31, no. 6, 1965, p. 169-181. 10 refs. In German.

Method for calculating the maximum specific impulse for a certain propellant from the calorific reaction value and the mean molar mass of the exhaust gases and computation of a certain parameter which can be used for propellant evaluation. The range of ballistic missiles or the useful payload of space carrier rockets depends on the specific impulse which the combination of propellants attains under operational conditions. It is shown that the combustion temperature is not the determining parameter for specific impulse.
D. P. F.

A66-21396 #

OPTIMIZATION OF THE HIGH-ENERGY TURBOPUMP UNIT ENGINE FOR THE ELDO-B CARRIER ROCKET [DIE OPTIMIERUNG DES HOCHENERGETISCHEN TURBOPUMPEN-EINHEITSTRIEBWERKS FÜR DIE ELDO-B-TRÄGERRAKETEN].
O. Stumpf (Entwicklungsring Nord, Bremen, West Germany).
Wissenschaftliche Gesellschaft für Luft- und Raumfahrt, Europäischer Luftfahrtkongress, 6th, Munich, West Germany, Sept. 1-4, 1965, Paper. 23 p. 11 refs. In German.

Analysis of the operating parameters of the third stage of the Eldo-B rocket and optimization of the combustion chamber pressure, expansion ratio, mixture ratio, combustion chamber, and nozzle contours. The concept of specific impulse is discussed in terms of rocket performance optimization. The design and characteristics of the 6×10^3 kg thrust Eldo-B third stage rocket engine are described. The propellant mixture is H_2-O_2 and the total propellant carried weighs 14 metric tons. The optimal combustion chamber pressure is of the order of 40 kg/cm^2. The optimum expansion ratio is derived for varying values of operating parameters. The optimum propellant ratio is 5 kg of O_2 per kg of H_2; the optimized nozzle parameters are plotted. The optimum pump speeds are 14,000 to 17,000 rpm for the O_2 pump and 50,000 to 65,000 for the H_2 pump.
D.P.F.

A66-21715

PROBLEMS OF HYBRID ROCKET ENGINES [PROBLEME DER HYBRIDRAKETENANTRIEBE].
A. Moutet (ONERA, Châtillon-sous-Bagneux, Seine, France).
Luftfahrttechnik Raumfahrttechnik, vol. 12, Jan. 1966, p. 10-16. In German. (Translation).

Survey of ONERA research and development efforts in the field of hybrid rocket engines. Special attention is given to the problem of stable fuel burning and to the experimental determination of the burning rate. H_2O_2 and Al + plastic filler, NO_3H and Al + plastic filler, ClO_4NO_2 and N_2O_4, ClF_3 and HLi, ClF_3 and Li, N_2O_4 and H_2Be, H_2O_2 and H_2Be, F_2 and HLi, F_2 and O_2 + plastic filler, F_2 and He_2Be, O_2 and H_2Be, and F_2 and AlH_3 are the hybrid fuels considered. Thrust modulation, ignition delay and the use of tricomponent fuels are discussed. Individual types of hybrid rocket engines are briefly described.
V.Z.

A66-21776 #

THERMOMECHANICAL RESPONSE STUDIES OF SOLID PROPELLANTS SUBJECTED TO CYCLIC AND RANDOM LOADING.
R. A. Schapery (Purdue University, School of Aeronautics, Astronautics and Engineering Sciences, Lafayette, Ind.) and D. E. Cantey (Lockheed Aircraft Corp., Lockheed Propulsion Co., Redlands, Calif.).
(American Institute of Aeronautics and Astronautics, Solid Propellant Rocket Conference, 6th, Washington, D.C., Feb. 1-3, 1965, Paper 65-160.)
AIAA Journal, vol. 4, Feb. 1966, p. 255-264. 8 refs.
USAF-supported research.

An analytical and experimental study of the interaction between heating and dynamic response of solid propellants is presented. Emphasis is placed on the evaluation of linear viscoelastic theory in predicting thermomechanical behavior and also on the nature of the interaction between displacement, stress, and temperature response. For analytical and experimental simplicity, the investigation deals with a specimen that is loaded in simple shear and insulated such that heat flow is restricted to occur normal to the direction of shear. Two types of loading are considered: constant displacement amplitude and inertial driving by means of an attached mass. The response to both harmonic and stationary random loading processes is determined analytically, and it is shown for both cases that large temperature increases may occur in the specimen with attached mass because of thermal instabilities. Good agreement between experiment and theory was obtained over most of the range of strain and frequency, but some stress-strain nonlinearity and gradual propellant degradation were observed. (Author)

A66-21941 #

STABILITY BOUNDARIES OF LIQUID-PROPELLED ELASTIC SPACE VEHICLES WITH SLOSHING.
Helmut F. Bauer (Georgia Institute of Technology, School of Engineering Mechanics, Atlanta, Ga.).
Journal of Spacecraft and Rockets, vol. 3, Feb. 1966, p. 240-246. 5 refs.

Parametric study of means for eliminating, in the case of large elastic space vehicles, the undesirable coupling between bending, sloshing, and control, with determination of the amount of damping necessary for the propellant in the tanks. Since the fundamental lateral bending frequency is very small and close to the propellant and control frequency, the interaction of the elastic vehicle propellant motion and control is important in the design of the space vehicle and its control system. For a space vehicle in which the propellant of only one container is free to oscillate, the magnitude and location of the danger zone depends strongly upon the location of the control gyroscope. If the gyro location exhibits positive slope, propellant baffling is required only in a small zone around the center of instantaneous rotation. For the negative-bending-mode slope at the gyro location, the danger zone is large and the requirement for damping of the propellant is greatly increased. Keeping the control, sloshing, and bending frequencies well separated is found to yield - with the proper control system - reasonable baffle requirements to maintain vehicle stability. F. R. L.

A66-21945 #

EFFECTS OF GRAIN CONFIGURATION UPON THE BURNING RATE OF A SPINNING ROCKET MOTOR.
J. Michael Murphy and Richard H. Wall (Thiokol Chemical Corp., Engineering Dept., Huntsville, Ala.).
Journal of Spacecraft and Rockets, vol. 3, Feb. 1966, p. 263, 264. 10 refs.

Study indicating that the change in ballistic performance experienced by spinning rocket motors can be attributed to internal gas dynamics and combustion effects, and that the grain geometry influences the internal gas dynamics. The study also indicated that the effect of grain deformation on the performance of the motor in a radial acceleration environment was, at most, a secondary effect.
F.R.L.

A66-21946 #

FAILURE BEHAVIOR OF COMPOSITE HYDROCARBON FUEL BINDER PROPELLANTS.
T. M. Jones and R. B. Kruse (Thiokol Chemical Corp., Structural Integrity Section, Huntsville, Ala.).
(American Institute of Aeronautics and Astronautics, Solid Propellant Rocket Conference, 6th, Washington, D.C., Feb. 1-3, 1965, Paper 65-156.)
Journal of Spacecraft and Rockets, vol. 3, Feb. 1966, p. 265-267. 6 refs.
Army-supported research.

A66-21951 #

EFFECT OF LIQUID NITROGEN DILUTION ON LOX IMPACT SENSITIVITY.

C. F. Key (NASA, Marshall Space Flight Center, Chemical Compatibility Unit, Huntsville, Ala.) and J. B. Gayle (NASA, Marshall Space Flight Center, Propulsion and Vehicle Engineering Laboratory, Materials Div., Applied Chemistry Section, Huntsville, Ala.).

Journal of Spacecraft and Rockets, vol. 3, Feb. 1966, p. 274-276.

Summary of an experimental investigation of the effects of LN_2 dilution on the LOX impact sensitivity of selected materials, using the Army Ballistic Missile Agency LOX impact tester. In principle, a standard plummet of known weight is dropped from a known height, striking a pin resting on a layer of the material being tested, which is located in the bottom of an aluminum cup filled with LOX/LN_2 mixture. During the test, a material capable of reacting with the test mixture will explode and/or flash brilliantly. Materials tested included metals, elastomers, composite insulations, and foams. Results indicated that relatively large proportions of LN_2 were required to reduce the reaction frequencies or to increase the threshold energy levels appreciably. F. R. L.

A66-21952 #

THEORETICAL AND EXPERIMENTAL PRESSURES AND FORCES ON A RING BAFFLE UNDER SLOSHING CONDITIONS.

Luis R. Garza (Southwest Research Institute, Dept. of Mechanical Sciences, San Antonio, Tex.).

Journal of Spacecraft and Rockets, vol. 3, Feb. 1966, p. 276-278.

Contract No. NAS 8-1555.

Comparison of nondimensional theoretical and experimental pressures and forces acting on a flat ring baffle under sloshing conditions, in order to obtain more exact knowledge of baffle loading, so that lighter-weight baffles can be designed. Experiments were conducted with a ring baffle which was split in half, one half attached rigidly to the tank wall, and the other half supported by three force measuring dynamometers. The tank was force-excited horizontally in steady harmonic motion at the first liquid resonance frequency, or at a slightly higher frequency corresponding to maximum baffle loading. Comparisons are made for various baffle depths and for three values of tank excitation amplitudes. Force measurements for various perforated baffles are also presented. F. R. L.

A66-22221 #

AN ANALYSIS OF PARTICLE FORMATION EFFICIENCY IN A COLLOID THRUSTOR.

Daniel S. Goldin and George L. Kvitek (NASA, Lewis Research Center, Cleveland, Ohio).

American Institute of Aeronautics and Astronautics, Electric Propulsion Conference, 5th, San Diego, Calif., Mar. 7-9, 1966, Paper 66-253. 20 p. 29 refs.

Members, \$0.75; nonmembers, \$1.50.

Desirable propellant properties and upper limits on particle formation efficiency are determined for a homogeneous condensation-type colloid thrustor. A simple physical model is used to describe the condensation process via an energy balance analysis. Basically the latent heat rejected by condensation must be absorbed by all possible energy sinks, which for realistic thrustors are (1) the noncondensed vapor in the stream, (2) the volume energy of the particles, and (3) the directed translational energy of the particles. The analysis shows that desirable propellant characteristics are (1) low molecular weight, (2) low ratio of actual latent heat to that given by Trouton's Rule, (3) high stagnation pressure, and (4) high gaseous specific heat ratio. An idealized upper limit to particle formation efficiency via homogeneous stream condensation is determined to be of the order of 50%. When considered as part of the overall thrustor efficiency, these results raise serious doubts regarding the potential usefulness of a number of colloid thrustor concepts. (Author)

A66-22249

A FUEL FOR HYBRID ROCKETS.

Ulf Magnusson (Svenska Flygmotor AB, Trollhättan, Sweden).

World Aerospace Systems, vol. 2, Feb. 1966, p. 50-52.

Discussion of Tagaform, a synthetic fuel which is hypergolic with white and red fuming nitric acids. It consists mainly of a polymer of an aromatic amine and a low molecular weight aldehyde. The polymerization is carried out under such conditions that the original hypergolicity of the amine is preserved. By the addition of a small quantity of boron-containing substance to Tagaform, it has been found possible to obtain an ignition delay of approximately 2 msec. Two methods of measuring the ignition delay are briefly discussed. Because it has a regression rate 5 to 10 times higher than for certain conventional fuels, Tagaform is considered to be well suited for many applications. Some performance figures are presented. Among other properties significant in choosing a hybrid rocket fuel, Tagaform features simplicity of manufacture, safety and simplicity of handling, storability, and smokeless combustion. In spite of a below-normal strength in tension and elongation, experiments indicate that Tagaform behaves very well in both static and flight tests. F.R.L.

A66-22460 #

THE CHEMISTRY OF SUBLIMING SOLIDS FOR MICRO THRUST ENGINES.

Alexander P. Hardt, W. M. Foley, and R. L. Brandon (Lockheed Aircraft Corp., Lockheed Missiles and Space Co., Materials Sciences Laboratory, Palo Alto, Calif.).

(American Institute of Aeronautics and Astronautics, Propulsion Joint Specialist Conference, Colorado Springs, Colo., June 14-18, 1965, Paper 65-595.)

Astronautica Acta, vol. 11, Sept.-Oct. 1965, p. 340-347. 19 refs.

Research supported by the Lockheed Independent Research Program and NASA.

A66-23589 #

SENSITIVITY OF COMPOSITE AND DOUBLE-BASE PROPELLANTS TO SHOCK WAVES.

Nathaniel L. Coleburn (U.S. Naval Ordnance Laboratory, Silver Spring, Md.).

AIAA Journal, vol. 4, Mar. 1966, p. 521-525. 17 refs.

Plane shock-wave compressions of cylindrical and wedge-shaped specimens were used to obtain the shock Hugoniots of two unreacted, composite, and double-base, aluminized propellants. The double-base propellant contained a hybrid explosive mixture. Optical measurements were made of the shock velocity buildup to steady detonation velocity as a function of travel distance in the wedge-shaped specimens. These measurements showed the double-base propellant to be as sensitive to rapidly applied shocks as cast composition B. Under similar pressures (>80 kbars), the composite propellant burned uneventfully without detonating. (Author)

A66-23648

NONMONOTONICITY IN SENSITIVITY TEST DATA.

J. B. Gayle (NASA, Marshall Space Flight Center, Huntsville, Ala.).

Materials Research and Standards, vol. 6, Mar. 1966, p. 147, 148.

Liquid oxygen impact tests on a Mylar-aluminum-Mylar laminate bonded to polyester foam yielded an apparently anomalous response. Tests on the material were then repeated until a statistically significant set of data was obtained. The cause of this irregular behavior was traced to the polyester foam, although an exact mechanism could not be determined owing to the complex initiation reaction. The authors conclude that, although instances of nonmonotonicity are rare, such occurrences will likely also be found in other tests of the stimulus-response type. The analyst is cautioned against attributing all abnormal responses to experimental error. (Author)

A66-23867
HYBRID ROCKET MOTOR HR 4 [HYBRIDRAKETMOTOR HR 4].
Björn Ankarswärd (Svenska Flygmotor AB, Uddevalla, Sweden).
Teknisk Tidskrift, vol. 96, Mar. 9, 1966, p. 201-203. In Swedish.
Description of an experimental rocket which uses a hybrid rocket motor with fuming nitric acid as the oxidizer and a mixture of polyesters and acrylic plastics as the other solid propellant. The rocket motor consists of three sections - a gas generator, a tank for the oxidizer, and a combustion chamber which has a solid propellant molded along its wall. The gunpowder charge for the gas generator is ignited electrically; the hot gases react against a piston forcing it down through the cylindrical oxidizer tank. Thus, fuming nitric acid is forced under pressure and at a high velocity into the combustion chamber where the solid propellant ignites hypergolically. The acceleration is equal to 7 g, and a peak velocity of Mach 1.08 is attained. When burnout occurs, the rocket is at an altitude of about 1000 m; it then gains altitude in a ballistic trajectory up to a maximum of about 5 km. Recovery is effected by parachute. The motor length is 1.05 m, rocket diameter is 100 mm, and total thrust is 1300 kg.
D. P. F.

A66-24522 #
ADVANCED LOW-THRUST PROPULSION SYSTEMS FOR STATION KEEPING AND STABILITY CONTROL OF THE NASA MANNED ORBITAL RESEARCH LABORATORY (MORL) - RESISTOJETS AND RADIOISOTOPE THRUSTORS.
Milton Goodman (Douglas Aircraft Co., Inc., Missile and Space Systems Div., Propulsion Branch, Santa Monica, Calif.).
American Institute of Aeronautics and Astronautics, Electric Propulsion Conference, 5th, San Diego, Calif., Mar. 7-9, 1966, Paper 66-226. 32 p. 6 refs.
Members, $0.75; nonmembers, $1.50.
Presented are results of a preliminary evaluation of resistojets, arcjets, ion engines, radioisotope thrustors, and catalytic monopropellant engines. Descriptions, specifications, and stabilization and control requirements are given for the zero-g and artificial-g spin modes with two electric power configurations: (1) solar cell, and (2) Brayton cycle power system. Propellant resupply occurs every 90 days by use of an Apollo logistics vehicle. Propellants studied included cryogenic hydrogen and space storable ammonia and hydrazine. Also included is an assessment of the propellant potential of carbon dioxide, hydrogen, and water in the biowaste resulting from the environmental control and life support cycle. The stabilization and control studies indicated that the drag makeup and attitude control functions previously performed by 50-lb thrust chemical engines, firing for a few seconds per orbit, can be accomplished with millipound thrust engines. The millipound thrust engines may be used in nearly continuous operation in conjunction with control moment gyros. Liftoff, resupply, and 5-yr mission weight comparisons resulted in the selection of resistojets and radioisotope thrustors for further detailed studies. (Author)

A66-24703 #
EFFECTS OF MATERIAL NONLINEARITY AND FAILURE CRITERIA UPON SOLID-PROPELLANT INTEGRITY.
John N. Majerus and Masao Tamekuni (Aerojet-General Corp., Sacramento, Calif.).
(American Institute of Aeronautics and Astronautics, Solid Propellant Rocket Conference, 6th, Washington, D.C., Feb. 1-3, 1965, Paper 65-158.)
Journal of Spacecraft and Rockets, vol. 3, Mar. 1966, 393-399. 15 refs.

A66-24704 #
MECHANICAL BEHAVIOR OF CAST-DOUBLE-BASE PROPELLANTS IN ROCKET MOTORS.
H. M. Darwell (Imperial Metal Industries /Kynoch/, Ltd., Summerfield Research Station, Ballistics and Mathematical Services Dept., Kidderminster, Worcs., England), A. Parker, and H. Leeming (Imperial Metal Industries /Kynoch/, Ltd., Summerfield Research Station, Propellant Dept., Kidderminster, Worcs., England).
(American Institute of Aeronautics and Astronautics, Solid Propellant Rocket Conference, 6th, Washington, D.C., Feb. 1-3, 1965, Paper 65-161.)
Journal of Spacecraft and Rockets, vol. 3, Mar. 1966, p. 399-407. 9 refs.

A66-24705 #
A CUMULATIVE-DAMAGE CONCEPT FOR PROPELLANT-LINER BONDS IN SOLID ROCKET MOTORS.
K. W. Bills, Jr. (Aerojet-General Corp., Mechanical Properties Laboratories, Sacramento, Calif.), G. J. Svob, R. W. Planck, and T. L. Eriksson (Aerojet-General Corp., Sacramento, Calif.).
(American Institute of Aeronautics and Astronautics, Solid Propellant Rocket Conference, 6th, Washington, D.C., Feb. 1-3, 1965, Paper 65-191.)
Journal of Spacecraft and Rockets, vol. 3, Mar. 1966, p. 408-412. 7 refs.
USAF-supported research.

A66-24706 #
BONDING OF COMPOSITE PROPELLANT IN CAST-IN-CASE ROCKET MOTORS.
Clarence Gustavson, Thomas W. Greenlee, and Avery W. Ackley (Aerojet-General Corp., Propellant Research Div., Liner Research Section, Sacramento, Calif.).
Journal of Spacecraft and Rockets, vol. 3, Mar. 1966, p. 413-418. 27 refs.
Contract No. AF 04(611)-8538.
Study of the bonding of a number of polyurethane and polybutadiene composite propellants in cast-in-case rocket motors. The apparent bond strength of these propellants when bonded to elastomeric substrates is found to be governed by the propellant cohesive strength. When these propellants are tested, either by the tensile method or the peel method, failure is invariably found to be cohesive

A66-24707 #
DESIGN PROCEDURES FOR COMBUSTION TERMINATION BY NOZZLE AREA VARIATION.
R. L. Coates, C. F. Price (Lockheed Aircraft Corp., Lockheed Propulsion Co., Engineering Research Dept., Redlands, Calif.), and R. E. Polzien (Lockheed Aircraft Corp., Lockheed Propulsion Co., Engineering Branch, Redlands, Calif.).
(American Institute of Aeronautics and Astronautics, Solid Propellant Rocket Conference, 6th, Washington, D.C., Feb. 1-3, 1965, Paper 65-194.)
Journal of Spacecraft and Rockets, vol. 3, Mar. 1966, p. 419-425. 13 refs.

A66-25160
CHEMICAL KINETICS AND HYPERSONIC FLOW.
Howard B. Palmer (Pennsylvania State University, Dept. of Fuel Technology, University Park, Pa.).
IN: FUNDAMENTAL PHENOMENA IN HYPERSONIC FLOW; PROCEEDINGS OF THE INTERNATIONAL SYMPOSIUM, BUFFALO, N.Y., JUNE 25, 26, 1964. [A66-25152 13-12]
Symposium sponsored by the Cornell Aeronautical Laboratory. Edited by J. G. Hall.

Ithaca, N.Y., Cornell University Press, 1966, p. 175-190; Prepared Comment, K. L. Wray (Avco Corp., Avco-Everett Research Laboratory, Everett, Mass.), p. 190-194; Floor Discussion, D. E. Rosner (AeroChem Research Laboratories, Inc., Princeton, N.J.), p. 194. 51 refs.
Research supported by Project Squid, J. M. Huber Corp., Army, NSF, and AEC.

Discussion of several important chemical problems including the relationship between dissociation and recombination kinetics, the kinetics of high-temperature air, the thermal decomposition of hydrazine, and the thermal decomposition of some hydrocarbons. Shock-tube studies have contributed data required for the solution of these problems; such tubes assume an accurate knowledge of the coupling of gas flow and chemical reactions. If the shock velocity can be determined the conditions immediately behind the shock-front can be calculated. The manner in which the shock tube can be applied to the specific problems enumerated is described and past work on these problems is reviewed. D. P. F.

A66-25181 #
BURNING OF COMPOSITE AMMONIUM PERCHLORATE BASED PROPELLANTS NEAR THEIR EXTINCTION PRESSURE.
Lyman Richard Feinauer, Jr.
AIAA Student Journal, vol. 3, Dec. 1965, p. 125-128. 15 refs.

The decomposition of ammonium perchlorate was studied at pressures near the extinction pressure of the propellant. The first propellant studied consisted only of ammonium perchlorate and a copolymer of polybutadiene and acrylic acid as binder. The burning surface of this propellant was uniform with ammonium perchlorate crystals protruding from the binder matrix. When 2% carbon black was added to this propellant, no effect on the burning rate was noted except at pressures less than 3 psia. Apparently, at pressures below 3 psia, radiation losses caused the burning rate to fall below that of the simple ammonium perchlorate-binder propellant first mentioned. When a copper chromite burning rate catalyst was added to the noncarbon-containing propellant, erratic burning occurred at pressures below 1 psia. Although the effects of the binder are apparently small at high pressures, the character of the binder produces a significant influence on the propellant burning rate at low pressures. The subatmospheric pressure condition provided slower combustion which allowed for more detailed observations than were possible at high pressures. Although the burning rate data and other qualitative results apply only to the region studied, they provide insight into the burning processes and also into the role played by additives, catalysts, and fuel binders. (Author)

A66-26116
EFFECT OF RATE AND SUPERIMPOSED PRESSURE ON TENSILE PROPERTIES OF COMPOSITE SOLID PROPELLANT.
I. G. Hazelton (Aerojet-General Corp., Sacramento, Calif.).
IN: HIGH SPEED TESTING; INTERNATIONAL SYMPOSIUM, 5TH, BOSTON, MASS., MARCH 8, 9, 1965, PROCEEDINGS. VOLUME 5. [A66-26105 13-18]
Applied Polymer Symposia, no. 1, 1965.
Symposium sponsored by Plas-Tech Equipment Corp.
New York, Interscience Publishers, 1965, p. 217-228. 9 refs.

The failure properties of a composite solid propellant were determined over a range of strain rates and pressures corresponding to the tensile environment of propellants in large rocket motors during firing. A brief description is presented for a test apparatus for performing various mechanical property tests under superimposed gas pressure up to 1000 psi (70.3 kg/cm^2) at crosshead rates from 0.5 to 7500 in./min (1.2-1900 cm/min). Data presented indicate propellant tensile properties are greatly influenced by superimposed pressure and higher strain rates. The effects of temperature and moisture are also discussed. (Author)

A66-26117
MICROSTRUCTURAL RESPONSE AND TENSILE FAILURE MECHANISMS IN SOLID PROPELLANTS.
F. N. Kelley (USAF, Systems Command, Research and Technology Div., Rocket Propulsion Laboratory, Edwards AFB, Calif.).
IN: HIGH SPEED TESTING; INTERNATIONAL SYMPOSIUM, 5TH, BOSTON, MASS., MARCH 8, 9, 1965, PROCEEDINGS. VOLUME 5. [A66-26105 13-18]
Applied Polymer Symposia, no. 1, 1965.
Symposium sponsored by Plas-Tech Equipment Corp.
New York, Interscience Publishers, 1965, p. 229-246. 16 refs.

This investigation was directed toward the elucidation of solid propellant tensile failure mechanisms through careful characterization of constitutive effects, such as those produced by binder backbone polarity, crosslink density variations, and filler fraction. Ultimate property data are represented by time- and temperature-independent "failure envelopes" as originally suggested by Smith. These data were obtained at extension rates varying from 0.02 to approximately 10,000 in./min and at 0, 80, and 180°F. A detailed method for the determination of crosslink density in filled systems is presented utilizing equilibrium swollen state tensile and compression techniques. These methods are compared with more conventional volume swelling procedures, and polymer-solvent interaction (X_1) values are tabulated for several systems. Failure data are normalized to fit master curves based on crosslink density and filler fraction shifts. Creep compliance measurements on unfilled binder samples permit an evaluation of the Bueche-Halpin tensile strength theory. Reasonable predictions of filled system behavior for three widely differing propellant families, i.e., polyurethane, carboxy-terminated polybutadiene, and poly(butadiene-acrylic acid-acrylonitrile), result. (Author)

A66-26119
METHODS OF CHARACTERIZATION OF POLYMERIC MATERIALS BY HIGH SPEED TESTING TECHNIQUES.
Courtland N. Robinson and Phillip H. Graham (Atlantic Research Corp., Mechanical Properties Section, Alexandria, Va.).
IN: HIGH SPEED TESTING; INTERNATIONAL SYMPOSIUM, 5TH, BOSTON, MASS., MARCH 8, 9, 1965, PROCEEDINGS. VOLUME 5. [A66-26105 13-18]
Applied Polymer Symposia, no. 1, 1965.
Symposium sponsored by Plas-Tech Equipment Corp.
New York, Interscience Publishers, 1965, p. 261-270. 6 refs.

Discussion of two cases in which high-speed testing techniques have been applied in the study of the time-dependent mechanical properties of materials used in solid propellant rockets. The materials tested are a composite solid propellant and a crystalline polymer, TFE Teflon. It is demonstrated that high-speed testing techniques, involving the use of the time-temperature superposition principle and the Williams-Landel-Ferry equation, can be used to characterize completely the mechanical behavior of viscoelastic materials and to provide information for the solution of problems which would otherwise be difficult to undertake. A. B. K.

A66-27413 #
SOME OBSERVATIONS ON THE COMBUSTION OF N_2H_4 DROPLETS.
B. R. Lawver (Aerojet-General Corp., Sacramento, Calif.).
(American Institute of Aeronautics and Astronautics, Annual Meeting, 2nd, San Francisco, Calif., July 26-29, 1965, Paper 65-355.)
AIAA Journal, vol. 4, Apr. 1966, p. 659-662. 8 refs.
Research supported by Aerojet-General Corp.

A66-27414 #
THERMAL DIFFUSIVITY OF AMMONIUM PERCHLORATE.
Willis A. Rosser, Jr., S. Henry Inami, and Henry Wise (Stanford Research Institute, Dept. of Chemical Dynamics, Menlo Park, Calif.).
AIAA Journal, vol. 4, Apr. 1966, p. 663-666. 17 refs.
Navy-supported research.

A method has been developed to measure the thermal diffusivity of poorly conductive materials. The method is absolute and rapid, requires only small samples, and is applicable to material with diffusivities in the range from 1×10^{-4} cm^2/sec to 5×10^{-2} cm^2/sec. Tests with Plexiglas, pyrex, quartz, and single crystal NaCl indicate that the method is accurate. The thermal diffusivity of pressed NH_4ClO_4 and NaCl powders has been measured as a function of porosity. For both materials, the observed linear decrease of diffusivity with porisity can be described by a single compaction parameter. The thermal diffusivity of compressed NH_4ClO_4 powders has been measured as a function of temperature from room temperature to 240°C, the temperature at which the crystal form changes from orthorhombic to cubic. In the cited temperature range, the thermal diffusivity χ_0(cm²/sec) of nonporous polycrystalline NH_4ClO_4 varies with temperature T(°C) according to the expression $\chi_0 = 2.50 \times 10^{-3} - 4.55 \times 10^{-6}$ T. (Author)

A66-27426 #
EXPERIMENTAL INVESTIGATION OF BIPROPELLANT ARC.
H. O. Noeske and J. C. Glass (North American Aviation, Inc., Rocketdyne Div., Canoga Park, Calif.).
AIAA Journal, vol. 4, Apr. 1966, p. 716-718. 7 refs.
Contract No. NAS 8-1647.

Experimental investigation and development of a lithium-hydrogen arcjet for demonstrating the feasibility of running a stable lithium-hydrogen arcjet, where the arc burns in lithium and indirectly heats a cool hydrogen vortex that surrounds the arc. The experimental setup and the results are described. It is shown that a gas temperature of 3000° to 4000°K must be assumed. Accepting this as the temperature at the boundary of the arc column, the arc-core temperature may reach 4500° to 6000°K, which corresponds to an ionization degree between 5 and 15%. With the foregoing temperature assumptions, there is reasonable agreement between theory and experiment. M.M.

A66-27451 #
EXPLOSION OF PROPELLANTS.
Robert F. Fletcher (NASA, Manned Spacecraft Center, Advanced Spacecraft Technology Div., Mission Feasibility Branch, Houston, Tex.), Clark Goodman (Houston Research Institute, Inc.; Houston, University, Dept. of Physics, Houston, Tex.), and Dal Gerneth.
(American Physical Society, Meeting, Norman, Okla., Feb. 1965, Paper.)
AIAA Journal, vol. 4, Apr. 1966, p. 755-757. 7 refs.
Contract No. NAS 9-2640.

Consideration of the application of certain work to the problem of explosion of liquid propellants, both in vacuum and in an atmosphere. The objective is to give both an upper bound to overpressures on a surface near such an explosion and also an estimate for overpressures on a surface at some distance from such an explosion. It was found that the yield given by pressures at the 10-ft gages were smaller than those given by the other gages, indicating the shock was still supported at that distance. The results are summarized in figures, and it is noted that the curve for overpressure in an atmosphere refers to static overpressure only. M.M.

A66-27488
INVESTIGATION AIMED AT DECREASING RANDOM TRANSVERSE-THRUST COMPONENTS BY VARYING THE NOZZLE PROFILE IN THE REGION OF THE NOZZLE THROAT [UNTERSUCHUNGEN ÜBER DIE VERMINDERUNG WILLKÜRLICHER QUERSCHUBKOMPONENTEN DURCH VARIATION DER SCHUBDÜSENPROFILE IM BEREICH DES DÜSENHALSES].
Winfried Buschulte and Klaus Schadow (Deutsche Forschungsanstalt für Luft- und Raumfahrt, Institut für Strahlantriebe, Trauen, West Germany).
Zeitschrift für Flugwissenschaften, vol. 14, Apr. 1966, p. 194-201. In German.

Development of a method for suppressing the random transverse thrust components that arise in the combustion phase in rockets and particularly in solid-propellant rockets. The method is designed specifically to reduce transverse components of the type that cause a continuous change in the desired direction of the thrust vector. Model experiments are described which led to the development of a nozzle profile that is not affected by radial forces in the subsonic range. V.P.

A66-27489
PERIODIC PROCESSES IN THE COMBUSTION MECHANISM OF COMPOSITE PROPELLANTS [PERIODISCHE VORGÄNGE IM ABBRANDMECHANISMUS VON COMPOSITE-TREIBSTOFFEN].
Horst Selzer (Deutsche Forschungsanstalt für Luft- und Raumfahrt, Institut für Strahlantriebe, Trauen, West Germany).
Zeitschrift für Flugwissenschaften, vol. 14, Apr. 1966, p. 202-206. In German.

Experimental investigation of pulsating features of the, at first glance, continuous combustion mechanism of composite propellants. Measurements for the propellant AP-PIB resulted in a time constant of 40 msec for the reaction variation at a pressure of 1 kg/cm², and for the propellant AP-PU, in a time constant of 70 msec measured at a pressure of 132 kg/cm². A model for the combustion process is proposed. V.P.

A66-27560 #
FINITE-RATE BURNING OF A MONOPROPELLANT DROPLET IN A STAGNANT ATMOSPHERE.
Francis E. Fendell (Thompson Ramo Wooldridge, Inc., TRW Systems Group, Aerosciences Laboratory, Aerophysics Dept., Redondo Beach, Calif.).
Astronautica Acta, vol. 11, Nov.-Dec. 1965, p. 418-421.

The quasi-steady spherically symmetric burning of a monopropellant liquid droplet is examined for Lewis number unity under a first-order one-step irreversible decomposition. Because most monopropellants readily react, the zero-activation-energy limit is chosen. The pure-fuel droplet undergoes adiabatic vaporization approximately at its boiling temperature in this model and reacts in an infinite expanse of stagnant product gas. Because the exact formal solution is analytically intractable, the asymptotic limits of large first Damkohler number (nearly equilibrium conditions) and of small first Damkohler number (nearly frozen conditions) are examined, both by means of singular perturbations. Formulas are developed for the mass transfer rate, which plays the role of an eigenvalue in the two-point boundary-value problem that is formulated. These formulas are compared with previous results obtained for the high-activation-energy limit. (Author)

A66-27566
SWEDISH PROPELLANTS FOR HYBRID ROCKET MOTORS [SVENSKT BRÄNSLE FÖR HYBRIDRAKETMOTOR].
Ulf Magnusson (Svenska Flygmotor AB, Trollhättan, Sweden).
Teknisk Tidskrift, vol. 96, Apr. 13, 1966, p. 365-368. In Swedish.

Description of propellants for rocket motors developed in Sweden consisting of the condensation product of liquid aromatic amines and aldehydes of low molecular weight as the solid fuel and fuming nitric acid as the oxidizer. When the nitric acid comes in contact with such polymerized condensation products ignition is hypergolic. The pressure developed in the combustion chamber with this combination of propellants is 70 bars and the specific impulse was measured and found equal to 260 kg-sec/kg; the exhaust velocity was 2550 m/sec. D.P.F.

A66-27690 #
CRITERION OF INSTABILITY OF A DEVELOPED DEFLAGRATION AND THE ANALOGY BETWEEN THE COMBUSTION PROCESSES IN A DETONATION WAVE AND A ROCKET MOTOR [KRITERII NEUSTOICHIVOSTI RAZVITOI DEFLAGRATSII I ANALOGIIA PROTSESSA SGORANIIA V DETONATSIONNOI VOLNE I V RAKETNOM DVIGATELE].
S. K. Aslanov.
Aviatsionnaia Tekhnika, vol. 9, no. 1, 1966, p. 108-114. 7 refs. In Russian.

Theoretical analysis of the stability to small disturbances of the process of fast combustion of an inflammable compressible mixture. Dynamic conditions are considered for the process in which the prevailing mechanism is a successive self-ignition of mixtures of hot fuel components. An instability criterion for the process is developed in general form from a plane flame-front model. V.Z.

A66-28104
COMBUSTION AND HEAT TRANSFER IN A SMALL ROCKET CHAMBER BURNING LIQUID OXYGEN AND GASEOUS HYDROGEN.
A. T. Jeffs, C. Ramshaw, and B. W. A. Ricketson (Ministry of Aviation, Rocket Propulsion Establishment, Westcott, Bucks., England).
Spaceflight, vol. 8, May 1966, p. 172-184. 14 refs.
Results from a test program to study the practicability of gaseous hydrogen as a rocket fuel. Liquid oxygen and gaseous hydrogen were burnt in a chamber giving a nominal thrust of 450 lb. The construction of the motor and the analytical methods used are described. The test results are plotted and discussed. R.A.F.

A66-28442 #
A MATHEMATICAL MODEL FOR DEFINING EXPLOSIVE YIELD AND MIXING PROBABILITIES OF LIQUID PROPELLANTS.
E. A. Farber (Florida, University, Gainesville, Fla.).
IN: THE CHALLENGE OF SPACE; PROCEEDINGS OF THE THIRD SPACE CONGRESS, COCOA BEACH, FLA., MARCH 7-10, 1966. [A66-28401 14-30]
Congress sponsored by the Canaveral Council of Technical Societies. Cocoa Beach, Fla., Canaveral Council of Technical Societies, 1966, p. 510-519.
Contract No. NAS 10-1255.
This paper describes how a mathematical model can be constructed to fit theoretical or experimental data on yield and spill of liquid propellants. It shows how these primary quantities can be separated, how probability distributions can be found for each, and how probability confidence regions and confidence limits can be established. The fundamental function of this very general mathematical model, based upon four independent parameters, and the characteristics of the resulting probability surface are discussed in detail. The mathematical model, programmed for an IBM 709 computer, is applied to some spill test data of liquid propellants for which the necessary information is available and then with a minimum number of assumptions to missile failure yield estimates. (Author)

A66-28443 #
A SYSTEMATIC APPROACH FOR THE ANALYTICAL ANALYSIS AND PREDICTION OF THE YIELD FROM LIQUID PROPELLANT EXPLOSIONS.
E. A. Farber (Florida, University, Gainesville, Fla.) and J. H. Deese (NASA, Kennedy Space Center, Facilities Technology Office, Cocoa Beach, Fla.).
IN: THE CHALLENGE OF SPACE; PROCEEDINGS OF THE THIRD SPACE CONGRESS, COCOA BEACH, FLA., MARCH 7-10, 1966. [A66-28401 14-30]
Congress sponsored by the Canaveral Council of Technical Societies. Cocoa Beach, Fla., Canaveral Council of Technical Societies, 1966, p. 520-532.
Contract No. NAS 10-1255.
This paper presents a systematic approach by which the expected yield from liquid propellants can be predicted and furthermore gives an insight into the physical phenomena involved. The yield potential and the mixing function can be determined allowing for the type of propellants, their relative proportions, the reaction rates between the components depending upon mixture composition, the heat transfer rates between the components and the propellants and the surroundings, the mode of failure and the resulting mixing characteristics, and the ignition and reaction delay times. Combining the above information into seven charts as presented leads to a systematic analytical determination of the expected yield. (Author)

A66-28445 #
MISSILE EXPLOSION SIMULATION.
Robert O. Harper (General Electric Co., Missile and Space Div., Apollo Support Dept., Daytona Beach, Fla.).
IN: THE CHALLENGE OF SPACE; PROCEEDINGS OF THE THIRD SPACE CONGRESS, COCOA BEACH, FLA., MARCH 7-10, 1966. [A66-28401 14-30]
Congress sponsored by the Canaveral Council of Technical Societies. Cocoa Beach, Fla., Canaveral Council of Technical Societies, 1966, p. 540-546.
Evaluation of digital computer simulations of missile explosions which were run to provide an estimate of physical parameters that an explosion measurement system must measure. The computer simulations were run using the NOL "Wundy" hydrodynamic computer code (which is described) and a two-dimensional code. The initial calculations were made to provide good estimates of the magnitude and rate of change of physical parameters such as temperature, pressure, density, and velocity, which were to be remotely measured. Results derived include shock wave position as well as static and dynamic pressure, particle velocity, temperature, density, and energy as functions of both elapsed time and distance from the center of the explosion. B.B.

A66-28795 #
PRODUCT ASSURANCE OF METALS FOR MISSILES AND SPACE.
Harold W. Williams, Jr. (Atlantic Research Corp., Propulsion and Chemical Systems Div., Alexandria, Va.).
IN: AMERICAN SOCIETY FOR QUALITY CONTROL, ANNUAL TECHNICAL CONFERENCE, 19TH, LOS ANGELES, CALIF., MAY 3-5, 1965, TRANSACTIONS. [A66-28788 15-15]
Milwaukee, Wis., American Society for Quality Control, Inc., 1965, p. 160-165.
Application of reliability analysis of structural components to the specific case of propellant tanks for rocket engines. The hemispheres used to close off each end of the tank were made from a blank which was spun, trimmed, and then heat treated. An analysis of variance in hemisphere strength indicated that the spinning operation was the greatest source of variance among hemispheres and that within hemisphere reliability the variance was tolerable. Statistical tolerance limits in the regression plane were computed using Weissburg and Beatty's technique; this computation provided the relationship between the trim stock ultimate strength and a proportion P of the ultimate strength values selected on this basis, at the 80% confidence level. D. P. F

A66-29237 #
KINETICS OF THE DECOMPOSITION OF BH_3PF_3 AND RELATED COMPOUNDS - A REVISED ESTIMATE OF THE DISSOCIATION ENERGY OF DIBORANE.
Anton B. Burg and Yuan-Chin Fu (Southern California, University, Dept. of Chemistry, Los Angeles, Calif.).
American Chemical Society, Journal, vol. 88, Mar. 20, 1966, p. 1147-1151. 10 refs.
Contract No. Nonr-228(13); NSF Grants No. G-14669; No. GP-199.
Very sensitive infrared procedures were used to show that the compounds BH_3PF_3, $BH_3 \cdot CF_3PF_2$, and $BH_3 \cdot (CF_3)_2PF$ all decompose to B_2H_6 and free phosphine ligand by the same mechanism as found earlier for BH_3CO, namely, the dissociation of BH_3L to BH_3 and free ligand L, followed by action of BH_3 to displace L from BH_3L. The same rate law applies also to the far more complicated case of $B_4H_8PF_3$. Extrapolation of early-stage rate data for BH_3PF_3 to zero time gave first-order rate constants for initial dissociation at three temperatures. These results, taken with the overall equilibria, led to $D(BH_3\text{-}BH_3) = 35.0$ kcal, consistent with but more precise than earlier estimates. The only systematic error here would arise from the reasonable assumption that $\Delta H = 0$ for activation of the reverse of the initial dissociation. (Author)

A66-29289 #
REGRESSION RATES OF METALIZED HYBRID FUEL SYSTEMS.
L. D. Smoot (Lockheed Aircraft Corp., Lockheed Propulsion Co., Engineering Research Dept., Research Branch, Redlands, Calif.) and C. F. Price (Lockheed Aircraft Corp., Lockheed Propulsion Co., Engineering Research Dept., Research Branch, Combustion Section, Redlands, Calif.).
AIAA Journal, vol. 4, May 1966, p. 910-915.
Contract No. DA-04-495-AMC-218(Z).
This paper summarizes theoretical and experimental investigations of regression rates of metalized hybrid fuel systems with application to the lithium hydride-butyl rubber-fluorine-oxygen system. Influences of pressure, oxidizer flow, and oxidizer and

fuel-grain composition on regression rate were determined using a laboratory-scale slab burner. Experimental regression rates were independent of pressure and increased with 0.8 power of flow rate in regions of low flow rate. For high flow rates, the regression rate was independent of flow but varied markedly with pressure. Increasing the percent of lithium hydride reduced pressure dependence and increased regression rate. Increasing the percent of fluorine increased the regression rate. Predictions from the classical hybrid regression rate law based on turbulent heat transfer, extended to include the effects of condensed-phase surface products, were compared with experimental data. Agreement was good in low flow-rate regions, but the model did not account for the observed pressure dependence. (Author)

A66-29298 #
SHOCK WAVE INTERACTION WITH A BURNING SOLID PROPELLANT.
of vibration control. Thermal fatigue presentation is illustrated in terms of cooled turbine blading. The need to be mindful of the meaning of material strength factors in assuring high time, high cycle life engines is suggested in the treatment of cycling-rupture-vibration interactions. Increasingly precise analysis and experimental verification as an integral part of the design process make possible the increasingly complex design execution and attainment of design goal (Author)

A66-29308
IGNITION OF COMPOSITE PROPELLANT FUELS BY PERCHLORIC ACID VAPOR.
G. S. Pearson and D. Sutton (Ministry of Aviation, Rocket Propulsion Establishment, Research Div., Westcott, Bucks., England).
AIAA Journal, vol. 4, May 1966, p. 954-956. 11 refs.
Consideration of the mechanism of ignition of solid propellants, particularly that of composite propellants containing ammonium perchlorate as the oxidizer. Of two different mechanisms proposed on the basis of experimental data, one proposes that the important exothermic reactions that lead to ignition occur between fuel and oxidizer gases in the vapor phase close to the propellant surface, and the other proposes that the exothermic reactions occur between gaseous oxidizer and condensed fuel at the fuel surface. The processes are extensively discussed, and a table of ignition delays of various propellants, obtained experimentally, is presented. It is concluded that both mechanisms appear tenable and that the relative importance of each may depend on such factors as the heat flux, the pressure level within the motor, and the vapor pressure or the ease of pyrolysis of the fuel. F.R.L.

A66-29610
EFFECT OF PRESSURE ON RATE OF BURNING (DECOMPOSITION WITH FLAME) OF LIQUID HYDRAZINE.
A. C. Antoine (NASA, Lewis Research Center, Cleveland, Ohio).
Combustion and Flame, vol. 10, Mar. 1966, p. 86-89. 6 refs.
Examination of the decomposition process of liquid hydrazine in glass tubes, in order to determine what chemical or physical changes may be occurring that cause the abrupt breaks in the burning rate/pressure curves. Measurements were made of the flame temperature and of the light emission; in addition, color photographs and visual observations were made of the decomposition flame. The results of the flame temperature measurements in a 5.6-mm-diam tube are tabulated. It is seen that, within the experimental error, the maximum gas temperature is not dependent on pressure or on burning rate. The amount of light emitted from combustion in the tube was measured at various pressures and is tabulated. It is concluded that there are no changes in mechanism that can be attributed to a change in the course of the overall reaction. The observations made suggest that physical and not kinetic factors change the apparent order of the reaction. M.F.

A66-30466
SLOSH CONTROL BY DIELECTROPHORESIS.
L. R. Koval and P. G. Bhuta (TRW, Inc., TRW Systems Group, Special Projects Section, Redondo Beach; Southern California, University, Dept. of Mechanical Engineering, Los Angeles, Calif.).
IN: INSTITUTE OF ENVIRONMENTAL SCIENCES, ANNUAL TECHNICAL MEETING, SAN DIEGO, CALIF., APRIL 13-15, 1966, PROCEEDINGS. [A66-30434 16-11]
Mt. Prospect, Ill., Institute of Environmental Sciences, 1966, p. 237-242. 8 refs.
Study of a means of controlling the sloshing motion of the liquid-vapor interface in space vehicle fuel tanks by use of a dielectrophoretic system. It is shown that the stability of the liquid-vapor interface can be enhanced by the presence of a dielectrophoretic device, and that the magnitude of the oscillations arising from environmental disturbances is reduced by use of the phenomenon of dielectrophoresis. Numerical results are given for systems with and without dielectrophoretic stabilization. B.B.

A66-30900 #
ANALYSIS OF CRYOGENIC PROPELLANT LOGISTICS.
Robert H. Lea, J. Gordon Drew (Martin Marietta Corp., Martin Co., Research and Engineering Div., Denver, Colo.), and Frank K. Wolf (Iowa, State University, Iowa City, Iowa).
(American Institute of Aeronautics and Astronautics, Air Force Logistics Command, and Aeronautical Systems Division, Support for Manned Flight Conference, Dayton, Ohio, Apr. 21-23, 1965, Paper 65-259.)
Journal of Spacecraft and Rockets, vol. 3, May 1966, p. 728-734.
Contract No. NAS 8-5159.

A66-30909 #
OPTIMUM DESIGN OF A PRESSURIZED MULTICELL CYLINDRICAL SHELL.
F. W. Niedenfuhr (Institute for Defense Analyses, Research and Engineering Support Div., Arlington, Va.) and C. W. Bert (Oklahoma, University, School of Aerospace and Mechanical Engineering, Norman, Okla.).
Journal of Spacecraft and Rockets, vol. 3, May 1966, p. 752-754.
Description of a simple method of reaching an optimum design of multicell shells. The geometry of a typical cell is illustrated, and the discussion leads to the design of an optimum membrane pressure vessel. It is pointed out that there are two advantages to the multicell tank. The internal webs provide an antislosh capability, and the multicell tank may be made from material which is thin enough to allow single pass welding. M.F.

A66-30913 #
BUBBLE BEHAVIOR IN LIQUIDS CONTAINED IN VERTICALLY VIBRATED TANKS.
Daniel D. Kana and Franklin T. Dodge (Southwest Research Institute, Dept. of Mechanical Sciences, San Antonio, Tex.).
(American Institute of Aeronautics and Astronautics, Aerospace Sciences Meeting, 3rd, New York, N.Y., Jan. 24-26, 1966, Paper 66-86.)
Journal of Spacecraft and Rockets, vol. 3, May 1966, p. 760-763. 5 refs.
Contract No. NAS 8-11045.

A66-31194
DETONABILITY OF CRYOGENIC OXIDIZERS - TRIOXYGEN DIFLUORIDE O_3F_2.
Adolph B. Amster, Joseph A. Neff, Roy W. McLeod, and Donald S. Randall (Stanford Research Institute, Menlo Park, Calif.).
Explosivstoffe, vol. 14, Feb. 1966, p. 33-35. 6 refs.
Contract No. NASr-49 (00).
Description of experiments in which a geometrical modification of the continuous wire technique was used to study the detonation

properties of O_3F_2 at 90°K. An apparatus specially developed for the experiment is described which makes it possible to discriminate between detonation and other explosive reactions. It was found that O_3F_2 does not detonate at this temperature, at least in the diameter tested (25 mm). V.P.

A66-31685 #
THE EFFECT OF LEAD STEARATE ON THE THERMODYNAMIC PROPERTIES OF A PROPELLANT.
Charles Lenchitz and Jean P. Picard (U.S. Army, Explosives and Propellants Laboratory, Picatinny Arsenal, Dover, N.J.).
Symposium on Theories of Combustion and Mechanism of Catalytic Activity in Propellant Combustion, Redstone Arsenal, Ala., May 6, 1965, Paper. 28 p. 7 refs.
Study of the role of lead stearate in the process of propellant combustion, using the heat-of-explosion test. It is shown that lead stearate affects both the strand burning rate and the heat of explosion in a similar manner. It is confirmed by chemical analysis that lead stearate affects the chemistry of the combustion process. It is shown that, although lead stearate increases the radiant energy of the propellant flame, this energy does not significantly affect the temperature of the propellant beneath the burning surface. A.B.K.

A66-32157 #
EFFECT OF HYDRAZINE ON CARBOHYDRATE METABOLISM IN VIVO AND IN VITRO.
Sidney R. Fortney (USAF, Systems Command, Aerospace Medical Div., School of Aerospace Medicine, Brooks AFB, Tex.).
IN: AEROSPACE MEDICAL ASSOCIATION, ANNUAL SCIENTIFIC MEETING, 37TH, LAS VEGAS, NEV., APRIL 18-21, 1966, PREPRINTS. [A66-32134 17-04]
Washington, D.C., Aerospace Medical Association, 1966, p. 73, 74. Abridged.
Experimental demonstration that one of the earliest effects observed after hydrazine injection, in addition to previously observed effects on blood glucose, is elevation of arterial lactate and pyruvate. The levels of these carbohydrate intermediates increased five- to tenfold within one hour after injection. The data from a fasted anesthetized dog are tabulated, and are discussed. The effect of hydrazine on oxidative phosphorylation in rat liver mitochondria was studied and the results tabulated. It was found that hydrazine markedly inhibited oxygen consumption when both pyruvate and α-ketoglutarate were substrates. An investigation in vitro was made of the effect of hydrazine on mitochondrial glutamic-oxaloacetic transaminase (GOT). GOT activity in rat liver mitochondria was found to be very susceptible to hydrazine, with marked inhibition at 1/10 the concentration needed to inhibit oxygen consumption. F.R.L.

A66-32203 #
LOX-COMPATIBLE PACKAGING FILMS.
Dan C. Anderson (Allied Chemical Corp., Morristown, N.Y.).
American Association for Contamination Control, Annual Technical Meeting and Exhibit, 4th, Miami Beach, Fla., May 25-28, 1965, Paper. 4 p.
$0.50.
Study of the use of plastic bags to maintain the cleanliness of supercleaned components in the aerospace and related fields. Necessary characteristics of the packaging material are described. It is concluded that when a packaged component or system is to contact LOX or a similar violent oxidizer, its bag or wrapping should be a film such as Aclar or other LOX-compatible material. B.B.

A66-32205 #
PRODUCTION CLEANING OF SATURN BOOSTER PROPELLANT TANK.
R. K. Olson and W. L. Howard (Boeing Co., New Orleans, La.).
American Association for Contamination Control, Annual Technical Meeting and Exhibit, 4th, Miami Beach, Fla., May 25-28, 1965, Paper. 6 p.
$0.50.
Description of the apparatus and methods used to clean the interior of the propellant and oxidizer tanks for the Saturn S-IC. The oxidizer tank, 33 ft in diameter and 64 ft long, will hold 350,000 gal of liquid oxygen and must therefore be cleaned to very exacting standards. R.A.F.

A66-32451 #
RELATIONSHIP BETWEEN FILLER DISTRIBUTION AND UNIAXIAL RUPTURE OF COMPOSITE SOLID PROPELLANTS.
Norman Fishman (Stanford Research Institute, Polymer and Propulsion Science Div., Menlo Park, Calif.).
AIAA Journal, vol. 4, June 1966, p. 1044-1049. 17 refs.
Research sponsored by the Stanford Research Institute; Contract No. AF 04(611)-9559.
Based on a study of the dilatational behavior of composite solid propellants, the paper discusses a detailed examination of specimen anisotropy developed during tensile elongation to rupture. As a specimen is extended uniaxially, particles become packed more tightly in the lateral plane perpendicular to the axis of extension. Calculated values of lateral area fraction of particles at rupture for each of several systems, based on constant strain rate, constant loading rate, and constant load test data, were within a range of ±2.5% about the mean, with a standard deviation of less than 2.5%. Upon closer examination of the results, it became apparent that the calculated values depended on the extension ratio. The data from each system were fitted with a modified exponential curve; standard deviations from the regression curve ranged from 0.4 to 0.8% and the over-all range of residuals was generally less than ±1%. Consideration of such redistribution of particles, in conjunction with a concept of localized regions of maximum lateral packing density, provides a new approach for understanding particle-binder interaction mechanisms leading to rupture. (Author)

A66-32458 #
MECHANISM OF COMBUSTION OF LIQUID ROCKET PROPELLANTS - ALIPHATIC ALCOHOLS AND MIXED ACID.
R. P. Rastogi and K. Kishore (Gorakhpur, University, Chemistry Dept., Gorakhpur, India).
AIAA Journal, vol. 4, June 1966, p. 1083-1085. 5 refs.
Research sponsored by the Council of Scientific and Industrial Research, India.
Experimental investigation of the ignition of a new propellant consisting of mixed acid and aliphatic alcohols, along with the mechanism of ignition. Measurements were made by the cup-test method, and the results are tabulated. It appears that the minimum percentage of oleum in the mixed acid required for the ignition of alcohol is 30% by weight. Ignition delay in presence of various additives was also measured. It is shown that calcium and potassium permanganates are good catalysts for ignition. This probably may be caused by production of atomic oxygen that accelerates the oxidation of alcohols. The heats of ignition with potassium permanganate as an additive were also measured for various alcohols. M.M.

A66-32853
MASS SPECTROMETRIC INVESTIGATION OF THE PYROLYSIS OF BORANES. IV - DIBORANE.
Anthony B. Baylis, George A. Pressley, Jr., and Fred E. Stafford (Northwestern University, Dept. of Chemistry and Materials Research Center, Evanston, Ill.).
American Chemical Society, Journal, vol. 88, June 5, 1966, p. 2428-2433. 21 refs.
AEC-ARPA-supported research.
A mass spectrometer was used to observe directly the contents of a flow reactor in which diborane at low pressure was being pyrolyzed. Temperature, flow time, surfaces, and gas pressures were varied. Borane, BH_3, was clearly identified and its mass

spectrum measured. A novel method, involving the difference in reactivities of monomer and dimer, was used to distinguish between BH_x + ions due to neutral borane and to fragmentation of diborane. The formation of higher boranes was followed. Secondary process ions also were measured. (Author)

A66-33162
THE PROPELLANT TANKING COMPUTER SYSTEM.
N. L. Hoecker and J. M. Mathewson (General Electric Co., Command Systems Div., Apollo Support Dept., Daytona Beach, Fla.).
Society of Automotive Engineers, Advanced Launch Vehicles and Propulsion Systems Conference, Huntsville, Ala., June 14-16, 1966, Paper 660454. 12 p.
Members, $0.75; nonmembers, $1.00.

Description of the functions and operation of the propellant tanking computer system (PTCS) which performs the propellant-monitor and control function for Saturn IB and Saturn V vehicles. The PTCS is an electro-mechanical control system designed to automatically control the cryogenic-propellant replenish valves using data from either vehicle- or ground-located sensors. The system may be used with noncryogenic propellants such as RP-1 also. The PTCS has been designed using high-reliability components, worst case analysis, and a redundant channel for manual monitor and control. M.M.

A66-33165
STUDIES IN ADVANCED SPACE VEHICLE CONTAINERS.
J. F. Blumrich (NASA, Marshall Space Flight Center, Huntsville, Ala.).
Society of Automotive Engineers, Advanced Launch Vehicles and Propulsion Systems Conference, Huntsville, Ala., June 14-16, 1966, Paper 660460. 14 p.
Members, $0.75; nonmembers, $1.00.

Discussion of the requirements necessitating studies concerning advanced space container design. They include prolonged storage time of cryogenic liquids, and the need for improved container configurations. Anticipated storage times range from a few weeks to many months. Both the effect of low temperatures as well as stringent insulation requirements influence the design of the tank and its support structure. Improvement of container configurations is necessary, essentially, for economical reasons. Work done so far resulted in several schemes and in the definition of their principles and design criteria. M.M.

A66-33237 #
A STUDY OF HETEROGENEOUS DETONATIONS.
E. K. Dabora, K. W. Ragland, and J. A. Nicholls (Michigan, University, Dept. of Aerospace Engineering, Aircraft Propulsion Laboratory, Ann Arbor, Mich.).
(American Institute of Aeronautics and Astronautics, Aerospace Sciences Meeting, 3rd, New York, N.Y., Jan. 24-26, 1966, Paper 66-109.)
Astronautica Acta, vol. 12, Jan.-Feb. 1966, p. 9-16. 17 refs.
Contract No. NASr-54(07).

A66-33717
PROPELLANT CHEMISTRY.
S. F. Sarner (Thiokol Chemical Corp., Elkton, Md.).
New York, Reinhold Publishing Corp., 1966. 417 p.
$20.

A source book or prime reference for propellant data for the use of chemists, engineers, and students is offered, and several concepts of the energetics and behavior of propellants are introduced. An attempt has been made to relate the performance of propellants to the basic chemistry to increase the engineer's knowledge, and to acquaint the chemist with the next steps and the ultimate goals of the propellant he develops. Rocket background and the flight dynamics of rockets are first considered. Combustion thermodynamics and flight parameters, and thermodynamic functions from statistical mechanics are studied. Attention is given to the energetics and performance of propellant systems, recombination kinetics, and the kinetics of two-phase flow. Solid propellant binders, rocket propellant fuels, and rocket propellant oxidizers are described, and their properties discussed. The internal ballistics of solid propellants are examined. Two chapters are devoted to the testing and efficiency of propellants and advanced propulsion techniques. Five appendices tabulate heats of formation and densities of propellant ingredients, heats of formation of products of combustion, the interrelation of rocket parameters, functions of the specific heat ratio, and international atomic weights. F.R.L.

A66-33809 #
APPLICABILITY OF FLOX-LIGHT HYDROCARBON COMBINATIONS AS LIQUID ROCKET PROPELLANTS.
Arthur I. Masters (United Aircraft Corp., Pratt and Whitney Aircraft Div., Florida Research and Development Center, Applied Research Dept., West Palm Beach, Fla.).
(American Institute of Aeronautics and Astronautics, Propulsion Joint Specialist Conference, Colorado Springs, Colo., June 14-18, 1965, Paper 65-581.)
Journal of Spacecraft and Rockets, vol. 3, June 1966, p. 905-911.
Contract No. NAS 3-4195.

A66-33814 #
A DIRECT MEASURING RADIATION CALORIMETER FOR DETERMINING PROPELLANT GAS EMISSIVITY.
George T. Y. Chao, James C. Leslie, and Henry V. Mancus (Hercules Powder Co., Allegany Ballistics Laboratory, Cumberland, Md.).
(American Institute of Aeronautics and Astronautics, Annual Meeting, 2nd, San Francisco, Calif., July 26-29, 1965, Paper 65-358.)
Journal of Spacecraft and Rockets, vol. 3, June 1966, p. 928-930.

A66-33896
SELECTED METHODS FOR UPRATING SATURN VEHICLES.
Alfred G. Orillion and Ronald D. Scott (NASA, Marshall Space Flight Center, Huntsville, Ala.).
Society of Automotive Engineers, Advanced Launch Vehicles and Propulsion Systems Conference, Huntsville, Ala., June 14-16, 1966, Paper 660453. 11 p.
Members, $0.75; nonmembers, $1.00.

Discussion of selected methods for increasing the Saturn launch vehicle payload capabilities. These methods involve system changes or additions that give large step performance increases over those which can be obtained by product improvements. The selected philosophy of approach and the established designed systems are described, as well as anticipated system concepts that may be used to increase the Saturn vehicles' capabilities. M.F.

A66-34007
STRUCTURAL TANKS OF HYDROGEN-OXYGEN CRYOGENIC PROPULSION STAGES [RESERVOIRS STRUCTURAUX D'ETAGES PROPULSIFS CRYOGENIQUES HYDROGENE-OXYGENE].
J. Ménard and J. Triol (Société l'Air Liquide, Centre d'Etudes Cryogéniques, Service Etudes Spatiales, Sassenage, Isère, France).
Doc-Air-Espace, May 1966, p. 45-52. In French.

Examination in two steps of problems pertaining to cryogenic stages: at first the project itself, and then its development and testing. General details of cryogenic stages, and the physical characteristics of liquid hydrogen are discussed. To ensure ease of control of the motor, and for good insulation, it is desirable that the tank have a large diameter and a short length. Tank arrangement is studied. Thermal problems involving internal and external thermal flows and their effects on the behavior of the propellants are described. Attention is given to suitable structural materials (steel, light alloys) and to insulating materials. Comments are made on the types of tests required. F.R.L.

A66-34223 #

COMBUSTION OF THE N_2H_4/N_2O_4 PROPELLANT SYSTEM.

William H. Summers and E. T. McMullen (USAF, Systems Command, Research and Technology Div., Rocket Propulsion Laboratory, Edwards AFB, Calif.).

American Institute of Aeronautics and Astronautics, Propulsion Joint Specialist Conference, 2nd, Colorado Springs, Colo., June 13-17, 1966, Paper 66-662. 11 p. 9 refs.

Members, $0.75; nonmembers, $1.50.

An analytical and experimental investigation of the N_2H_4/N_2O_4 propellant system was undertaken to determine its reaction mechanisms at rocket chamber conditions. This investigation was made possible by a unique connection of a small water-cooled liquid-liquid combustor and a time-of-flight mass spectrometer. The results of the background atmospheric flame studies on H_2/NO_2, H_2/NO and NH_3/O_2 along with the engine performance (characteristic velocity C*) and the high temperature and pressure reaction mechanism of the N_2H_4/N_2O_4 propellant system will be reported. The preliminary data from this investigation indicates that the concentration of species in the rocket chamber may be in some instances greatly different from those predicted by thermodynamic equilibrium calculations. (Author)

A66-34225 #

IGNITION AND IGNITION PROPAGATION IN SOLID PROPELLANT MOTORS.

G. E. Jensen, R. S. Brown, D. A. Cose, and R. Anderson (United Aircraft Corp., United Technology Center, Sunnyvale, Calif.).

American Institute of Aeronautics and Astronautics, Propulsion Joint Specialist Conference, 2nd, Colorado Springs, Colo., June 13-17, 1966, Paper 66-677. 20 p. 16 refs.

Members, $0.75; nonmembers, $1.50.

Contracts No. NAS 7-156; No. NAS 7-329.

Study aimed at developing a basis for design and scaling of igniters and for analytical prediction of ignition chamber-pressure transients in solid motors. The approach used was to develop and substantiate experimentally a general theoretical model describing ignition and subsequent ignition propagation for rocket exhaust (pyrogen) and hypergolic-type igniters. Ignition delays, ignition propagation rates, and heat transfer rates were determined under controlled conditions as a function of igniter gas mass velocity, temperature, and concentration of hypergolic oxidizer. The theoretically predicted ignition propagation rates, using the measured heat transfer coefficients,were found to agree, within experimental error, with the experimentally observed ignition delays and flame spreading rates for all the gas mass velocities and gas temperatures tested. M.F.

A66-34226 #

CONTROL OF PRESSURE DEFLAGRATION LIMITS OF COMPOSITE SOLID PROPELLANTS.

John A. Peterson, Allan J. McDonald (Thiokol Chemical Corp., Wasatch Div., Applied Studies Dept., Brigham City, Utah), and Russell Reed, Jr. (Thiokol Chemical Corp., Wasatch Div., Propellant Research Section, Brigham City, Utah).

American Institute of Aeronautics and Astronautics, Propulsion Joint Specialist Conference, 2nd, Colorado Springs, Colo., June 13-17, 1966, Paper 66-679. 16 p. 7 refs.

Members, $0.75; nonmembers, $1.50.

Results of a research program conducted to develop solid propellant formulations that would not support combustion at ambient sea level pressure. The results obtained from this research program indicate that the low pressure deflagration limit (P_{dl}) of high energy propellants can be increased to superatmospheric pressures by various changes in propellant composition. M.F.

A66-34413 #

QUENCHING OF SOLID ROCKET PROPELLANTS BY DEPRESSURIZATION.

Edward A. Fletcher, Roger A. Paulson, Gene W. Bunde, and Tsuyoshi Hiroki (Minnesota, University, Dept. of Mechanical Engineering, Combustion Laboratory, Minneapolis, Minn.).

Combustion Institute, Western States Section, Spring Meeting, University of Denver, Denver, Colo., Apr. 25-27, 1966, Paper WSCI 66-21. 29 p. 14 refs.

NASA Contract No. 0635-5556.

Investigation of the phenomenon of solid rocket propellant quenching by depressurization. A physical model is constructed which describes what takes place during combustion; the process is considered to be one-dimensional. The gas-side heat transfer coefficient depends on the properties of the gas and the distribution of the chemical reaction, which in many respects is analogous to the reaction zone thickness in laminar one-dimensional flame theory. The effect of increased pressure results in a higher transfer rate to the solid. It is shown that the process of gasification depends on the temperature, exponentially, and that a regulating mechanism exists in which relatively small changes in surface temperature account for burning rate variations. D. P. F.

A66-34416 #

SOLID PROPELLANTS FOR SUPERSONIC COMBUSTION APPLICATIONS.

J. M. Murphy (Thiokol Chemical Corp., Huntsville Div., Huntsville, Ala.).

Combustion Institute, Western States Section, Spring Meeting, University of Denver, Denver, Colo., Apr. 25-27, 1966, Paper WSS/CI 66-32. 15 p. 8 refs.

Discussion of the features of solid propellants as applied to supersonic combustion applications. The characteristics of solid propellant for supersonic combustion are reviewed and the combustion properties of selected fuels and of solid propellants are tabulated. The potential performance of solid propellants in supersonic combustion systems is studied. It is concluded that the factors desirable in a fuel for supersonic combustion applications are possessed by solid propellants, and that systems employing solid propellant supersonic combustion are limited to shorter operating times than those using liquid fuels. M. F.

A66-34417 #

FUNDAMENTAL STUDIES OF COMPOSITE SOLID PROPELLANT DEFLAGRATION BY EXPERIMENTAL ANALOG TECHNIQUES.

Robert F. McAlevy, III, Suh Yong Lee, Vito R. DeTingo (Stevens Institute of Technology, Dept. of Mechanical Engineering, Combustion Laboratory, Hoboken, N.J.), and Frank A. Lastrina.

Combustion Institute, Western States Section, Spring Meeting, University of Denver, Denver, Colo., Apr. 25-27, 1966, Paper WSCI 66-25. 19 p. 8 refs.

Contract No. Nonr-263(48).

Results obtained with two different types of laboratory burners that are experimental analogs of the actual propellant deflagration process. These burners permit study of deflagration rate dependence on mixture ratio over a range that is an order of magnitude greater than that possible with actual propellants; further, they permit study of the deflagration rate dependence on either oxidant or fuel granularity as well as mixture ratio. The experimental approach is described. The results given include the influence of mixture ratio and pressure deflagration rate, the influence of fuel type on deflagration rate, and the effect of granularity on deflagration rate. The characteristics of actual composite propellant and those of analogous loose granule burner are tabulated. M.F.

A66-34419 #

A SIMPLE ANALYTICAL APPROACH TO CONSIDERATION OF KINETIC FACTORS IN DIFFUSION FLAMES, WITH EXAMPLES.

Gilbert S. Bahn (Marquardt Corp., Van Nuys, Calif.).

Combustion Institute, Western States Section, Spring Meeting, University of Denver, Denver, Colo., Apr. 25-27, 1966, Paper WSS/CI 66-10. 37 p. 13 refs.

Diffusion flames of CH_2-type hydrocarbon fuel in air, boron in air, and aluminum in the reaction products of ammonium perchlorate with solid-propellant hydrocarbon binder are examined theoretically. From simple chemical equilibrium calculations over a very wide range of fuel/oxidizer ratios, necessarily important intermediate reaction species are identified. If the fuel is a gaseous jet, and if reaction kinetics are essentially instantaneous so that turbulent mixing is controlling, the equilibrium calculations can be readily expressed in terms of flame geometry. If the fuel is a condensed-phase particle, simple spatial representation of equilibrium mole fractions reflects some distortion of the actual case where different species can be expected to have different molecular diffusivities and different reaction rates. Nevertheless, an important contribution to understanding of diffusion flame structure and kinetics is afforded. Examination of the results for hydrocarbon fuel in air leads to speculation that the time is now propitious for detailed analysis of the feasibility of chemical synthesis in hydrocarbon diffusion flames. From the results for boron in air, it appears that B_2O (i.e., B-O-B) may be a significant species near the burning boron particle, as yet undiscovered. The results for the aluminized solid propellant imply that chlorine from ammonium perchlorate may help to preclude encapsulation of the burning aluminum particle in a tight shell of alumina, by forestalling incidence of the latter near the particle surface and forcing it to appear only farther from the surface. Detailed chemical kinetics analyses of burning metal particles are urged as this field of combustion research receives increased attention. (Author)

A66-34420 #

THE COMBUSTION OF POROUS ALUMINUM PLUGS WITH OXYGEN THROUGHPUT.

Robert F. McAlevy, III, Suh Yong Lee, and Robert P. Wilson, Jr. (Stevens Institute of Technology, Dept. of Mechanical Engineering, Combustion Laboratory, Hoboken, N.J.).

Combustion Institute, Western States Section, Spring Meeting, University of Denver, Denver, Colo., Apr. 25-27, 1966, Paper WSCI 66-7. 15 p. 10 refs.

Contract No. Nonr-263(48).

Results of an experimental study of metal combustion in the porous-plug configuration. The metallic porous-plug burner technique appears to be the best available means of simulating the combustion characteristics of composite solid propellants heavily loaded with metallic additives - especially insofar as surface geometry and temperature are concerned. The fabrication of aluminum porous plugs is described. The different types of combustion described include aluminum "wool" combustion, aluminum bonded powder combustion, and aluminum mesh combustion. The dependence of aluminum "wool" surface regression rate and mass consumption rate, and the dependence of surface regression rate on $Al-O_2$ equivalence ratio for three types of porous plugs are plotted. M.F.

A66-34430 #

APPLICATION OF THE T-BURNER TO BALLISTIC EVALUATION OF NEW PROPELLANTS.

R. L. Coates (Lockheed Aircraft Corp., Lockheed Propulsion Co., Redlands, Calif.).

American Institute of Aeronautics and Astronautics, Propulsion Joint Specialist Conference, 2nd, Colorado Springs, Colo., June 13-17, 1966, Paper 66-599. 12 p.

Members, $0.75; nonmembers, $1.50.

Contract No. DA-04-495-AMC-239(R).

T-burner tests offer an excellent method for early combustion stability evaluation; results of recent work at Lockheed Propulsion Company, presented herein, illustrate this potential. The most recent testing with the T-burner has been directed toward evaluating the inherent combustion characteristics of hydrazine diperchlorate (HP_2). Simple propellants using this oxidizer were compared with similar formulations using ammonium perchlorate as the oxidizer. It was found that both the oscillating pressure growth constants and the reduced acoustic admittance of a nonaluminized formulation were roughly twice those obtained with AP oxidizer. A more striking observation was made from tests in which finely divided aluminum was added to the formulations. The addition of up to 5 percent aluminum to the HP_2 propellant had no stabilizing effect. In fact, the amplitude of oscillations was increased with the aluminum present. The results imply that further basic formulation work is required before extensive motor testing with this material is warranted. The results also illustrate benefits to be derived from laboratory-scale stability testing. (Author)

A66-34432 #

PARAMETRIC STUDY OF COMBUSTION INSTABILITY IN MMH-NTO LIQUID ROCKET ENGINE.

M. R. Beltran and T. C. Kosvic (Dynamic Science Corp., Propulsion Dept., Monrovia, Calif.).

American Institute of Aeronautics and Astronautics, Propulsion Joint Specialist Conference, 2nd, Colorado Springs, Colo., June 13-17, 1966, Paper 66-603. 20 p. 9 refs.

Members, $0.75; nonmembers, $1.50.

Contract No. AF 04(611)-10542.

The influence of storable liquid rocket engine parameters on combustion instability was determined by a parametric computer study. A basic configuration with a geometry similar to Transtage was chosen with monomethylhydrazine and nitrogen tetroxide used as propellants. This study investigates the influences of propellant mixture ratio, injection velocity, droplet size and distribution, and chamber pressure on the minimum pulse strength required to trigger instability. Steady-state properties at the most sensitive point are computed from a propellant vaporization program which can calculate decomposition and/or oxidation flames. Threshold pulse strength, as a function of steady-state variables, is computed from a nonlinear model. These limits determine the threshold for a tangential mode of high-frequency instability. Computer runs with the "two flame" model showed significant increases in the burning rate and decreases in stability over runs without "two flames." Also it was shown that for constant flow rate, there was a droplet size which produced minimum stability and stability increased with increasing injection velocity. Results of this study are related to experimental firings at USAF-RPL. (Author)

A66-34437 #

MEASUREMENTS OF HYDROGEN-FLUORINE KINETICS AT HIGH TEMPERATURES.

T. A. Jacobs, R. R. Giedt, and N. Cohen (Aerospace Corp., El Segundo, Calif.).

American Institute of Aeronautics and Astronautics, Propulsion Joint Specialist Conference, 2nd, Colorado Springs, Colo., June 13-17, 1966, Paper 66-637. 11 p.

Members, $0.75; nonmembers, $1.50.

USAF-sponsored research.

Examination of the measured rate coefficients for hydrogen-fluorine (HF) reactions. The decomposition of HF was studied in a shock tube over the temperature range ~3800 to 5300°K. The course of the decomposition was followed by recording the decay of IR emission from the fundamental vibration-rotation band of HP. Evidence is presented showing that optical densities were properly chosen to satisfy the requirements of transparent gas radiation; thus, recorded emission intensities could be related to HF concentrations. Extraction of the various rate constants from experimental HF concentration time histories required extensive use of a nonequilibrium digital computer program. For assumed values of the chemical rate tration-time histories and all other thermodynamic and rate histories of interest. Analysis of experimental data proceeded by matching observed and computed concentration-time histories. Rates derived for H plus F recombination were found to be in good numerical agreement with the theory of Benson and Fueno. M.F.

A66-34441 #

SOLID PROPELLANT IGNITION AND RESPONSE OF COMBUSTION TO PRESSURE TRANSIENTS.

Guenther von Elbe (Atlantic Research Corp., Alexandria, Va.).

American Institute of Aeronautics and Astronautics, Propulsion Joint Specialist Conference, 2nd, Colorado Springs, Colo., June 13-17, 1966, Paper 66-668. 16 p. 8 refs.

Members, $0.75; nonmembers, $1.50.

Solid-propellant burning is described in terms of a model which specifies that the propellant grain receives heat by conduction from the adjacent flame or igniting medium, that the heat flux from the flame to the grain surface responds instantly to changes of variables such as the ambient pressure, and that gasification of the propellant material occurs at the grain surface at a critical temperature T_s. Substantial support for the first-order validity of the model is provided by agreement between theoretical and experimental ignition lags of double-base and composite propellants. The temperature profile at the propellant surface responds to a pressure transient in the sense that for positive dp/dt the term k $(d^2T/dx^2)_s$ is larger than the steady-state value corresponding to any momentarily existing pressure p, and vice versa. In the former case the grain ablates (deflagrates) more rapidly than in the steady state at pressure p. In the latter case the grain becomes extinct at a critical rate of pressure decrease. The theoretical development yields substantial numerical agreement with experimental data on propellant extinction and reignition including L* instability. Furthermore, one is able to predict the pressure regime for chuffing and hangfire in rocket ignition. (Author)

A66-34580 #
THEORY OF IGNITION OF SOLID PROPELLANTS.
E. W. Price, G. L. Dehority (U.S. Naval Ordnance Test Station, Research Dept., Aerothermochemistry Group, China Lake, Calif.), H. H. Bradley, Jr., and M. M. Ibiricu (U.S. Naval Ordnance Test Station, China Lake, Calif.).
(American Institute of Aeronautics and Astronautics, Aerospace Sciences Meeting, 3rd, New York, N.Y., Jan. 24-26, 1966, Paper 66-64.)
AIAA Journal, vol. 4, July 1966, p. 1153-1181. 58 refs.
Navy-supported research.

A66-35240
OXIDATION AND COMBUSTION. XII - THE DEFLAGRATION OF SOLID AND HYBRID PROPELLANTS [OXYDATIONS ET COMBUSTIONS. XII - LA DEFLAGRATION DES PROPERGOLS SOLIDES ET HYBRIDES].
A. Van Tiggelen and J. Burger (Louvain, Université Catholique, Louvain, Belgium; Institut Français du Pétrole, des Carburants et Lubrifiants, Rueil-Malmaison, Seine-et-Oise, France).
Institut Français du Pétrole, Revue, vol. 21, May 1966, p. 816-868. 89 refs. In French.

Investigation of the combustion of solid or hybrid propellants with one or more solid phases. The properties of various propellants are described. One-dimensional theories applicable to the combustion of solid and hybrid propellants with transverse gas flow and non-one-dimensional theories for the case of erosive combustion and for longitudinal hybrid combustion are examined. D.P.F.

A66-35242
STABILITY OF SOME SELECTED PLASTICS TOWARD THE HYPERGOLIC ROCKET FUEL COMPONENTS AEROZINE AND DINITROGEN TETROXIDE [BESTÄNDIGKEIT AUSGEWÄHLTER KUNSTSTOFFE GEGENÜBER DEN HYPERGOLEN RAKETENTREIBSTOFFKOMPONENTEN AEROZIN UND DISTICKSTOFFTETROXID].
H. Meier zu Köcker (Entwicklungsring Nord, Bremen; Aachen, Technische Hochschule, Institut für Brennstoffchemie, Aachen, West Germany) and H. Weitzig (Entwicklungsring Nord, Bremen, West Germany).
Luftfahrttechnik Raumfahrttechnik, vol. 12, June 1966, p. 164-171. In German.

Discussion of the stability of various plastics to aerozine (a 1:1 mixture of hydrazine and unsymmetrical dimethylhydrazine) and N_2O_4. A table of experimental stability characteristics for several plastics is given. Only fluorohydrocarbons, notably tetrafluoroethylene, show lasting stability at temperatures up to 50°C. V.Z.

A66-35598 #
STRUCTURAL-ENVIRONMENTAL TESTS ON MULTILAYER INSULATION FOR CRYOGENIC SPACE VEHICLES.
Richard S. Nelson and John W. Anderson (Lockheed Aircraft Corp., Lockheed Missiles and Space Co., Sunnyvale, Calif.).
(AMERICAN INSTITUTE OF AERONAUTICS AND ASTRONAUTICS, STRUCTURES AND MATERIALS CONFERENCE, 6TH, PALM SPRINGS, CALIF., APRIL 5-7, 1965, p. 376-382.)
Journal of Spacecraft and Rockets, vol. 3, July 1966, p. 989-992.

A66-35609 #
REVIEW OF COMBUSTION STABILITY DEVELOPMENT WITH STORABLE PROPELLANTS.
R. J. Hefner (Aerojet-General Corp., Combustion Dynamics Dept., Sacramento, Calif.).
(American Institute of Aeronautics and Astronautics, Propulsion Joint Specialist Conference, Colorado Springs, Colo., June 14-18, 1965, Paper 65-614.)
Journal of Spacecraft and Rockets, vol. 3, July 1966, p. 1046-1051. 9 refs.

A66-35611 #
METHODS OF GAGING FLUIDS UNDER ZERO-G CONDITIONS.
A. D. Gronner (Simmonds Precision Products, Inc., Advanced Development Dept., Tarrytown, N.Y.).
(American Institute of Aeronautics and Astronautics, Annual Meeting, 2nd, San Francisco, Calif., July 26-29, 1965, Paper 65-365.)
Journal of Spacecraft and Rockets, vol. 3, July 1966, p. 1058-1062. 5 refs.

A66-35613 #
GROUND TESTS OF ORBITAL STORABILITY OF LIQUID PROPELLANTS.
Arnold D. Cohen (General Electric Co., Missile and Space Div., Valley Forge, Pa.) and Edward E. Stein (USAF, Systems Command, Research and Technology Div., Rocket Propulsion Laboratory, Edwards AFB, Calif.).
(American Institute of Aeronautics and Astronautics, Annual Meeting, 2nd, San Francisco, Calif., July 26-29, 1965, Paper 65-534.)
Journal of Spacecraft and Rockets, vol. 3, July 1966, p. 1069-1073. 6 refs.
Contract No. AF 04(611)-9078.

A66-35624 #
PRESSURE GRADIENTS IN A VARIABLE AREA LIQUID-PROPELLANT ROCKET MOTOR.
Louis J. Spadaccini (General Applied Science Laboratories, Inc., Westbury, N.Y.).
Journal of Spacecraft and Rockets, vol. 3, July 1966, p. 1128-1130.
Grant No. AF AFOSR 86-63.

Experimental study of the change in axial pressure gradients with geometry in combustion chambers formed by cylindrical and conical sections. The rocket motors employed were composed of a number of brass sections varying in diameter from 2 in. at the injector to a maximum of 4 in. elsewhere in the chamber. Liquid oxygen and JP-5A was burned, producing 500 lbf nominal thrust and chamber pressures between 110 and 140 psia. For a given set of injection parameters under stable operating conditions, results indicate that the recirculation zone was always found in a fixed region of the chamber, independent of length, but dependent on the entrance geometry. Because complete combustion should occur as soon as possible, it appears that a controlled recirculation of hot gases is desirable, and that a shape characterized by a large divergence angle at the injector face is best suited for this purpose. F.R.L.

A66-36233
WEIGHT OPTIMIZATION OF FLIGHT TYPE CRYOGENIC TANKAGE SYSTEMS.
Blase J. Sollami (Bendix Corp., Davenport, Iowa).
(American Chemical Society, Symposium, Atlantic City, N. J., Sept. 13, 1965, Paper.)
IN: ATMOSPHERE IN SPACE CABINS AND CLOSED ENVIRONMENTS.
Edited by Karl Kammermeyer.
New York, Appleton-Century-Crofts, Division of Meredith Publishing Co., 1966, p. 32-75.

Study of the cryogenic storage supply systems of oxygen and hydrogen both for fuel cell operation and for life support in manned spacecraft. In view of the large quantities of cryogen required weight optimization of reliable storage systems is a prime prerequisite. It is seen that the variables in the analysis include the quantity of cryogen, the vessel shape, standby time, and minimum tankage pressure. Two storage techniques are considered, one in which the nonvented storage concept is used and the other based on the vented concept. The parameters which mostly affect cryogenic system storage weight are discussed. For standby times of 90 to 270 days it was found that the nonvented system in spherical vessels yields the minimum weight for oxygen whereas vented storage in spherical tanks is optimal for hydrogen. D. P. F.

A66-36368
THERMODYNAMIC PROPERTIES OF GASES IN PROPELLANTS AND OXIDIZERS. I - SOLUBILITIES OF He, N_2, O_2, Ar, AND N_2O_3 IN LIQUID N_2O_4.
E. T. Chang and N. A. Gokcen (Aerospace Corp., Laboratories Div., Chemical Thermodynamics Section, El Segundo, Calif.).
Journal of Physical Chemistry, vol. 70, July 1966, p. 2394-2399. 15 refs.

The solubilities of gaseous He, N_2, O_2, Ar, and N_2O_3 in liquid N_2O_4 have been measured over a wide range of pressure and temperature. The results show conclusively that Henry's law is obeyed for He, N_2, O_2, and Ar at all pressures at each temperature and for N_2O_3 at low pressures. The standard free energy, enthalpy, and entropy of solution for each gas have been obtained. Thermodynamic arguments are presented to show the absence of reactions of N_2 and O_2 with N_2O_4. A qualitative argument is presented to explain the negative heats of solutions as resulting from the dissociation of N_2O_4 into NO_2 in the liquid. The equilibrium between NO(g) and dissolved N_2O_3 has also been presented. (Author)

A66-37059
ADVANCES IN CRYOGENIC ENGINEERING. VOLUME 11. PROCEEDINGS OF THE CRYOGENIC ENGINEERING CONFERENCE, WILLIAM MARSH RICE UNIVERSITY, HOUSTON, TEX., AUGUST 23-25, 1965.
Edited by K. D. Timmerhaus (Colorado, University, Engineering Research Center, Boulder, Colo.).
New York, Consultants Bureau, Division of Plenum Press, 1966. 712 p.
$19.50.

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SELF-SEALING SHIELDS FOR MICROMETEORITE PROTECTION. E. D. Funk (NASA, Marshall Space Flight Center, Huntsville, Ala.), p. 223-230. 8 refs. [See A66-37077 20-31]

THERMAL ANALYSIS AND OPTIMIZATION OF CRYOGENIC TANKS FOR LUNAR STORAGE. J. B. Romero, D. W. Smith, and R. E. Dod (Boeing Co., Seattle, Wash.), p. 231-240. 6 refs. [See A66-37078 20-33]

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EFFECT OF NUCLEAR RADIATION AND LIQUID HYDROGEN ON MECHANICAL PROPERTIES OF THREE PHENOLIC MATERIALS. W. Weleff (Aerojet-General Corp., Sacramento, Calif.), p. 486-491. [See A66-37097 20-18]

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COMPARATIVE STUDY OF FORCED CONVECTION BOILING HEAT TRANSFER CORRELATIONS FOR CRYOGENIC FLUIDS. P. J. Giarratano and R. V. Smith (National Bureau of Standards, Boulder, Colo.), p. 492-506. 22 refs. [See A66-37098 20-33]

BOILING HEAT TRANSFER FROM CYLINDERS IN A SATURATED LIQUID HELIUM II BATH. R. M. Holdredge and P. W. McFadden (Purdue University, West Lafayette, Ind.), p. 507-515.

NUCLEATE AND FILM BOILING HEAT TRANSFER TO NITROGEN AND METHANE AT ELEVATED PRESSURES AND LARGE TEMPERATURE DIFFERENCES. E. L. Park, Jr., C. P. Colver, and C. M. Sliepcevich (Oklahoma, University, Norman, Okla.), p. 516-529. 24 refs. [See A66-37099 20-33]

HEAT TRANSFER BY THE CIRCULATION OF SUPERCRITICAL HELIUM. H. H. Kolm, M. J. Leupold, and R. D. Hay (Massachusetts Institute of Technology, Cambridge, Mass.), p. 530-535.

COOLDOWN OF INSULATED METAL TUBES TO CRYOGENIC TEMPERATURES. J. P. Maddox and T. H. K. Frederking (California, University, Los Angeles, Calif.), p. 536-546.

A METHOD OF INCREASING HEAT TRANSFER TO SPACE CHAMBER CRYOPANELS. L. D. Allen (NASA, Manned Spacecraft Center, Tex.), p. 547-553. [See A66-37100 20-33]

CHILLDOWN AND STORAGE LOSSES OF LARGE LIQUID HYDROGEN STORAGE DEWARS. D. H. Liebenberg, R. W. Stokes, and F. J. Edeskuty (California, University, Los Alamos, N. Mex.), p. 554-560. 8 refs. [See A66-37101 20-11]

FURTHER EXPERIMENTAL STUDY OF H_2O-LH_2 HEAT EXCHANGERS. J. R. Bartlit and K. D. Williamson, Jr. (California, University, Los Alamos, N. Mex.), p. 561-567. 7 refs. [See A66-37102 20-33]

HEAT TRANSFER DOMAINS FOR FLUIDS IN A VARIABLE GRAVITY FIELD WITH SOME APPLICATIONS TO STORAGE OF CRYOGENS IN SPACE. S. H. Schwartz (Douglas Aircraft Co., Inc., Santa Monica, Calif.), p. 568-583. 32 refs. [See A66-37103 20-33]

A STUDY OF BUBBLE MOTION IN LIQUID NITROGEN. C. G. Fritz (NASA, Marshall Space Flight Center, Ala.), p. 584-592. 24 refs. [See A66-37104 20-12]

EQUIPMENT.

QUARTZ-TO-METAL AND LARGE DIAMETER METAL-TO-METAL RECYCLING CRYOGENIC HIGH-VACUUM SEALS. J. M.

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AN AUTOMATIC LIQUID NITROGEN DISTRIBUTION SYSTEM FOR TWENTY-FIVE COLD TRAPS. J. H. Fretwell and J. R. Bartlit (California, University, Los Alamos, N. Mex.), p. 601-606.
AN ELECTRICALLY PUMPED LIQUID HELIUM TRANSFER SYSTEM. B. Darrel and K. Schoch (General Electric Co., Schenectady, N.Y.), p. 607-611. [See A66-37105 20-11]
GAS BATH CRYOSTAT FOR WIDE-RANGE TEMPERATURE CONTROL. A. L. Blancett and F. B. Canfield (Oklahoma, University, Norman, Okla.), p. 612-616.
DESIGN OF PARA-ORTHOHYDROGEN CATALYTIC REACTORS. A. H. Singleton and A. Lapin (Air Products and Chemicals, Inc., Allentown, Pa.), p. 617-630.
A TECHNIQUE FOR DETERMINING THE LOCAL HEAT LEAK INTO A CRYOGENIC PIPE. E. R. Blanchard, B. S. Kirk, and S. H. Reiter (Air Reduction Co., Murray Hill, N.J.), p. 631-637.

SUPERCONDUCTIVITY AND MAGNETS.
HIGH-FIELD LIQUID-NEON-COOLED ELECTROMAGNETS. G. V. Brown and W. D. Coles (NASA, Lewis Research Center, Ohio), p. 638-642. [See A66-37106 20-23]
A SUPERCONDUCTING MAGNETIC BOTTLE. J. C. Laurence and W. D. Coles (NASA, Lewis Research Center, Ohio), p. 643-651. 6 refs. [See A66-37107 20-23]
CRITICAL STATE OF SUPERCONDUCTING SOLENOIDS. M. S. Lubell (Westinghouse Electric Corp., Pittsburgh, Pa.), p. 652-658.
THE PERFORMANCE OF LARGE SUPERCONDUCTING COILS. C. Laverick and G. M. Lobell (Argonne National Laboratory, Argonne, Ill.), p. 659-667.
CRYOGENICS AND ALUMINUM IN ELECTRICAL MANUFACTURING. P. Burnier (Société Générale de Constructions Electriques et Mécaniques Alsthom, Paris, France), p. 668-674.
DYNAMIC PROTECTION OF SUPERCONDUCTIVE COILS. S. H. Minnich (General Electric Co., Schenectady, N.Y.), p. 675-683.
SOME REMARKS ON CRYOGENIC CABLES. P. A. Klaudy (Graz, Technical University, Graz, Austria), p. 684-693.
A VIBRATING COIL MAGNETOMETER FOR USE AT VERY LOW TEMPERATURES. R. S. Kaeser, E. Ambler, and J. F. Schooley (National Bureau of Standards, Washington, D.C.), p. 694-698.

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A66-37060
THE IMPACT OF THE SPACE AGE ON CRYOGENICS.
A. O. Tischler (NASA, Office of Advanced Research and Technology, Washington, D.C.).
IN: ADVANCES IN CRYOGENIC ENGINEERING. VOLUME 11. PROCEEDINGS OF THE CRYOGENIC ENGINEERING CONFERENCE, WILLIAM MARSH RICE UNIVERSITY, HOUSTON, TEX., AUGUST 23-25, 1965. [A66-37059 20-23]
Edited by K. D. Timmerhaus.
New York, Consultants Bureau, Division of Plenum Press, 1966, p. 1-10.

Survey of the interrelationships between the U.S. space program and the cryogenic industry. The development of rockets using propellants which must be kept at very low temperatures is traced, and some of the current problems in the field are outlined. R.A.F.

A66-37074
FLUID HYDROGEN SLUSH - A REVIEW.
G. A. Cook and R. F. Dwyer (Union Carbide Corp., Linde Div., Tonawanda, N.Y.).
IN: ADVANCES IN CRYOGENIC ENGINEERING. VOLUME 11. PROCEEDINGS OF THE CRYOGENIC ENGINEERING CONFERENCE, WILLIAM MARSH RICE UNIVERSITY, HOUSTON, TEX., AUGUST 23-25, 1965. [A66-37059 20-23]
Edited by K. D. Timmerhaus.
New York, Consultants Bureau, Division of Plenum Press, 1966, p. 202-206. 12 refs.
USAF-supported research.

Discussion of the advantages in handling and storing hydrogen to be used as fuel for nuclear rockets in the form of a slurry of the solid in liquid instead of just as a liquid. This slurry is commonly referred to as hydrogen slush. The major potential advantages of slush over liquid hydrogen fall in the categories of reduction in evaporation loss during storage and handling, refrigeration, and density. In general, the most economical way of making hydrogen slush is by vacuum-pumping on the liquid with stirring. The liquid must be in a leak-tight vessel or in a vessel completely surrounded by an atmosphere of helium, so that air will not be drawn in during evacuation. M.M.

A66-37077
SELF-SEALING SHIELDS FOR MICROMETEORITE PROTECTION.
E. D. Funk (NASA, Marshall Space Flight Center, Huntsville, Ala.).
IN: ADVANCES IN CRYOGENIC ENGINEERING. VOLUME 11. PROCEEDINGS OF THE CRYOGENIC ENGINEERING CONFERENCE, WILLIAM MARSH RICE UNIVERSITY, HOUSTON, TEX., AUGUST 23-25, 1965. [A66-37059 20-23]
Edited by K. D. Timmerhaus.
New York, Consultants Bureau, Division of Plenum Press, 1966, p. 223-230; Discussion, R. B. Sherer (Air Products and Chemicals, Inc., Allentown, Pa.), V. J. Johnson (National Bureau of Standards, Washington, D.C.), and A. V. Pastuhov (Arthur D. Little, Inc., Cambridge, Mass.), p. 230. 8 refs.

Description of an experimental investigation of ways to seal a meteorite puncture in propellant tanks after it is produced. The results of the testing showed that the self-sealing shield is a very feasible method of protection for meteorite penetration, but many problems still exist. The effects of impact on the shield must be determined, because of the possibility that the porous material could shatter on impact or be destroyed by fragmentation of the meteorite. There appears to be a good possibility that larger penetrations could be sealed by the solid formation if the pressure drop length is increased. If a shield of the type studied can be proven to be completely reliable against impact effects, it may be applied as protection for low-pressure fluid transfer lines, space-vehicle fuel tanks, and storage tanks for storable fluids, such as water. M.M.

A66-37078
THERMAL ANALYSIS AND OPTIMIZATION OF CRYOGENIC TANKS FOR LUNAR STORAGE.
J. B. Romero, D. W. Smith, and R. E. Dod (Boeing Co., Seattle, Wash.).
IN: ADVANCES IN CRYOGENIC ENGINEERING. VOLUME 11. PROCEEDINGS OF THE CRYOGENIC ENGINEERING CONFERENCE, WILLIAM MARSH RICE UNIVERSITY, HOUSTON, TEX., AUGUST 23-25, 1965. [A66-37059 20-23]
Edited by K. D. Timmerhaus.
New York, Consultants Bureau, Division of Plenum Press, 1966, p. 231-239; Discussion, C. H. Reynales (Douglas Aircraft Co., Inc., Santa Monica, Calif.) and H. H. Kolm (Massachusetts Institute of Technology, National Magnet Laboratory, Lexington, Mass.), p. 239, 240. 6 refs.

Description of results of analytical work on the thermal analysis and weight optimization of low-heat-leak storage tanks. The results obtained indicated that the heat flow through insulated tank supports was nearly one-dimensional, that steady-state approximation was applicable, and that nonuniform surface temperatures equalized rapidly within the insulation. Oxygen tanks optimized at 1 to 2 in. of insulation and 200 to 400 psia, and hydrogen tanks at 3 to 4 in. and a pressure of 100 to 150 psia. Weight optimization was strongly dependent on support heat leakages, since a large fraction of the heat (approximately 60%) was through the supports. Cryogen storage was sensitive to insulation thickness, propellant mass stored, changes in construction material, and changes in the environment. Oxygen temperatures were especially sensitive to changes in insulation thickness and mass stored for small values of these parameters. M.M.

A66-37079
EXTRATERRESTRIAL CRYOGENIC PROPELLANTS RELIQUEFACTION.

T. A. Sedgwick (Marquardt Corp., Van Nuys, Calif.) and
R. L. Middleton (NASA, Marshall Space Flight Center, Huntsville, Ala.).
IN: ADVANCES IN CRYOGENIC ENGINEERING. VOLUME 11. PROCEEDINGS OF THE CRYOGENIC ENGINEERING CONFERENCE, WILLIAM MARSH RICE UNIVERSITY, HOUSTON, TEX., AUGUST 23-25, 1965. [A66-37059 20-23]
Edited by K. D. Timmerhaus.
New York, Consultants Bureau, Division of Plenum Press, 1966, p. 241-250. 6 refs.
Contract No. NAS 8-5298.

Examination of the elimination of cryogenic propellant boiloff losses in long-duration space storage by means of mechanical reliquefiers. Lunar, earth-orbit, and deep-space applications were considered for both hydrogen and oxygen. It was found that substantial savings can be achieved in the total mass which must be transported per unit mass of propellant available at the end of the storage period in the case of hydrogen. Preliminary design studies indicate that it is both feasible and desirable to operate the lunar reliquefiers only during the lunar night, when low-waste-heat radiator-operating temperatures are possible. The latter permit the use of relatively simple reliquefier thermodynamic cycles. The propellant tanks remain unvented during the lunar day and night. Several new approaches for storage periods of shorter duration appear attractive. These include the use of para-ortho conversion of hydrogen as the reliquefier heat sink and permitting some boiloff flow and using it as the reliquefier heat sink. M.M.

A66-37080
SATURN VEHICLE CRYOGENIC PROGRAMS.
R. D. Walker and B. J. Herman (NASA, Marshall Space Flight Center, Huntsville, Ala.).
IN: ADVANCES IN CRYOGENIC ENGINEERING. VOLUME 11. PROCEEDINGS OF THE CRYOGENIC ENGINEERING CONFERENCE, WILLIAM MARSH RICE UNIVERSITY, HOUSTON, TEX., AUGUST 23-25, 1965. [A66-37059 20-23]
Edited by K. D. Timmerhaus.
New York, Consultants Bureau, Division of Plenum Press, 1966, p. 251-258.

Description of the use and management of the cryogenic propellant program for Saturn applications. The use of more stringent purity requirements in this specific program is discussed. A short summary illustrating the magnitude of cryogenic applications is tabulated. At present most of the major planning has been completed and contracts have been consummated. M.M.

A66-37083
HAZARD STUDIES WITH HYDROGEN AND OXYGEN IN THE LIQUID AND SOLID PHASES.
S. Kaye (General Dynamics Corp., General Dynamics/Convair, San Diego, Calif.).
IN: ADVANCES IN CRYOGENIC ENGINEERING. VOLUME 11. PROCEEDINGS OF THE CRYOGENIC ENGINEERING CONFERENCE, WILLIAM MARSH RICE UNIVERSITY, HOUSTON, TEX., AUGUST 23-25, 1965. [A66-37059 20-23]
Edited by K. D. Timmerhaus.
New York, Consultants Bureau, Division of Plenum Press, 1966, p. 277-286.
Contract No. NAS 8-11405.

Determination of the nature and extent of the hazards associated with the ignition of the various condensed-phase hydrogen-oxygen systems. Studies were conducted under various conditions of total pressure, mixture ratio, ignition source, and confinement. Results show that hot surfaces, hot wires, sparks, and flames can ignite condensed-phase systems and solid hydrogen-liquid oxygen at pressures as low as 10 mm Hg. The solid hydrogen-solid oxygen system can be made to react by impact under high vacuum, but it appears that the reaction does not propagate beyond the impacting surfaces, except for one experiment in which a detonation occurred. The reaction wave of the unconfined propellants is generally characterized by slow, fairly long burning, and cool heterogeneously reacting zones. F.R.L.

A66-37159
ELECTROEXPLOSIVE DEVICES IN AEROSPACE VEHICLE SYSTEMS.
Sidney A. Moses (Douglas Aircraft Co., Inc., Missile and Space Systems Div., Santa Monica, Calif.).
(Institute of Electrical and Electronics Engineers, Aerospace Systems Conference, Seattle, Wash., July 11-15, 1966, Paper.) IEEE Transactions on Aerospace and Electronic Systems, Supplement, vol. AES-2, July 1966, p. 51-56.

Reasons for using electroexplosive devices in aerospace vehicles are given. A number of different electroexplosive devices are illustrated and their uses are described. The explosive materials used in these devices are discussed in two classes: propellants and high explosives. Methods for controlling deflagration or detonation to achieve desired effects are discussed. Construction of a typical electroexplosive cartridge is described, with special reference to the bridgewire-explosive system. A "bridgewire equation" is suggested for determining the functioning characteristics of the system. The method of determining the reliability of these "one-shot" items is compared to that used for devices which may be operated for a number of cycles. Safety of handling electroexplosive devices is discussed along with a few common-sense rules for accident prevention. (Author)

A66-37259 #
METHANE-FUELED PROPULSION SYSTEMS.
Richard J. Weber, James F. Dugan, Jr., and Roger W. Luidens (NASA, Lewis Research Center, Cleveland, Ohio).
American Institute of Aeronautics and Astronautics, Propulsion Joint Specialist Conference, 2nd, Colorado Springs, Colo., June 13-17, 1966, Paper 66-685. 16 p. 8 refs.
Members, $0.75; nonmembers, $1.50.

Discussion of the possibility of improving the performance of vehicles such as the SST through the use of liquid methane. Liquid methane fuel is superior to JP or kerosene in terms of heating value, cooling capacity, and possibly in cost and availability. When it is applied to the difficult commercial SST mission, it is estimated that the payload capacity can be increased by about 30% and the direct operating cost reduced a like amount. Because methane is a good thermodynamic working fluid, there exists the possibility of making further gains in aircraft performance by employing special engine cycles. Although the cryogenic nature of liquid methane poses unusual problems in handling, storage, and engine and airframe design, the magnitude of the potential gains warrants further analysis and experimental work to substantiate the merits of the concept. M.M.

A66-37632 #
DEVELOPMENT OF THE SURVEYOR VERNIER PROPULSION SYSTEM (VPS).
M. Edmund Ellion, H. DiCristina, A. R. Maffei (Hughes Aircraft Co., Los Angeles, Calif.), and A. Briglio, Jr. (California Institute of Technology, Jet Propulsion Laboratory, Pasadena, Calif.).
American Institute of Aeronautics and Astronautics, Propulsion Joint Specialist Conference, 2nd, Colorado Springs, Colo., June 13-17, 1966, Paper 66-593. 24 p.
Members, $0.75; nonmembers, $1.50.

Discussion of problems encountered during the development of the Surveyor vernier propulsion system (VPS) for soft landing the spacecraft on the lunar surface. The design concepts of the individual components are described, including the thrust chamber assemblies, the propellant tank assemblies with their positive expulsion Teflon bladders and standpipes as well as the helium tank and valves assembly including the pressure regulator and associated valves. In the VPS, the liquid propulsion feed components supply the necessary propellants under controlled conditions to three throttlable rocket engines. In the Surveyor mission, the VPS provides the proper thrust to accomplish midcourse guidance, attitude control during main retro firing, retro separation impulse, and final vehicle deceleration to a few feet above the moon's surface. M.M.

A66-38043
A STUDY OF DECOMPOSITION BURNING.
W. A. Rosser, Jr. (Stanford Research Institute, Menlo Park, Calif.) and R. L. Peskin (Rutgers University, New Brunswick, N.J.).
Combustion and Flame, vol. 10, June 1966, p. 152-160. 20 refs.
Research supported by the Stanford Research Institute, the American Petroleum Institute and NASA.

The decomposition burning of liquid hydrazines in the form of small spheres is reported. Some aniline and water were contained in the hydrazine. A theoretical decomposition model is proposed and examined. It shows that the mass burning rate is proportional to the radius only for very low reaction rates or in the evaporative limit. For high reaction rates the mass burning rate is proportional to the square of the radius. (Author)

A66-38140

HYPERGOLIC ROCKET PROPELLANTS - IGNITION BEHAVIOR OF LIQUID PROPELLANT COMBINATIONS AT REDUCED COMBUSTION CHAMBER PRESSURES [ÜBER HYPERGOLE RAKETEN-TREIBSTOFFE - DAS ZÜNDVERHALTEN FLÜSSIGER TREIBSTOFF-KOMBINATIONEN UNTER VERMINDERTEM BRENNKAMMER-DRUCK].

G. Spengler and J. Bauer (Deutsche Versuchsanstalt für Luft- und Raumfahrt, Institut für Flugtreib- und Schmierstoffe, Munich, West Germany).

Brennstoff-Chemie, Apr. 1966, p. 3-7. 5 refs. In German.

Investigation of the behavior of hypergolic liquid-propellant combinations. The apparatus used in the experiments to inject the propellant and the oxidizer into the combustion chamber is described. The effects of feed pressure, injection tube diameter, and the free path of the fluids from the tube ends to the point of collision on the ignition process are studied at pressures between 0.05 and 0.7 atm in the combustion chamber. It is found that the ignition behavior of all the propellant combinations studied deteriorated at low pressures. For components with different viscosity, the time to ignition was shortest at equal injection rates into the chamber. The free path of the fluids up to collision had no apparent effect on the ignition process. V. P.

A66-38258

METALLIZED LIQUID PROPELLANTS.

W. W. Wells (USAF, Systems Command, Research and Technology Div., Rocket Propulsion Laboratory, Edwards AFB, Calif.).

Space/Aeronautics, vol. 45, June 1966, p. 76-82.

Discussion of the possibility of improving the performance and safety of rocket engine systems using storable liquid propellants. In these metallized propellants, particularly the metallized liquids, gains in specific impulse and/or propellant density are not necessarily made at the cost of handling and storing convenience and safety. These liquids, which contain readily oxidized metal powders, offer gains in specific impulse and density that should lead to updated ICBMs and more compact tactical missiles. M. M.

A66-38296 #

COMPARATIVE ESTIMATE OF THE EFFECTS OF ADDITIVES ON JET PROPELLANTS [SRAVNITEL'NAIA OTSENKA DEISTVIIA PRISADOK DLIA REAKTIVNYKH TOPLIV].

Ia. B. Chertkov and V. M. Ignatov.

Khimiia i Tekhnologiia Topliv i Masel, vol. 11, June 1966, p. 53-56. 6 refs. In Russian.

Investigation of the effect of additions of (1) 2,6-di-tert-butyl-4-methylphenol (ionol, topanol O), (2) n-hydroxy diphenylamine, (3) a copolymer of methacrylic acid with β-diethylethanolamine and lauryl alcohol (FOA-2), and (4) an "Esso" additive (a C_{21} aliphatic amine with a tertiary carbon atom in the alkyl radical) on the performance of some jet propellants. Corrosion effects and the oxidation resistance of propellants with these additives are discussed. V. Z.

A66-38531

VACUUM-ULTRAVIOLET PHOTOCHEMISTRY. V - MOLECULAR ELIMINATION OF NITROGEN IN THE PHOTOLYSIS OF HYDRAZINE.

L. J. Stief and V. J. DeCarlo (Melpar, Inc., Research Div., Falls Church, Va.).

Journal of Chemical Physics, vol. 44, June 15, 1966, p. 4638, 4639. 7 refs.

Contract No. NASw-890.

Evidence for a mechanism for the formation of nitrogen in the photolysis of hydrazine which is entirely different from those suggested by Husain and Norrish (1963), Audrieth and Ogg (1951), and Noyes and Leighton (1941). Results from experiments using mixtures of hydrazine and hydrazine-^{15}N indicate that the overall mechanism for molecular elimination of N_2 from hydrazine may be represented as $N_2H_4 + h\nu \rightarrow N_2 + H_2 + 2H$. It is found that the major portion of the nitrogen formed is eliminated from a single molecule and not formed by radical-radical combinations. R. A. F.

A66-38688 #

THEORY OF PROPELLANT IGNITION BY HETEROGENEOUS REACTION.

F. A. Williams (California, University, Dept. of the Aerospace and Mechanical Engineering Sciences, La Jolla, Calif.).

AIAA Journal, vol. 4, Aug. 1966, p. 1354-1357.

Grant No. DA-ARO(D)-31-124-G747.

Laplace transform techniques are used to analyze ignition of solid or hybrid propellants by exothermic heterogeneous reactions in the presence of a simultaneous incident radiant energy flux. Ignition times are shown to be obtainable from the solution to a single nonlinear integral equation, for which an approximate numerical method of solution is suggested. Numerical results are presented for a parametric study of the limiting case of zero radiant energy flux. A simple formula for the ignition time is shown to provide a good correlation of the numerical results. (Author)

A66-39868

SPECIAL PROBLEMS IN CURING HIGHLY EXOTHERMIC PROPELLANTS.

Thomas E. Stonecypher, Edwin L. Allen, Donald E. Mastin, and Donald A. Willoughby (Rohm and Haas Co., Huntsville, Ala.).

(American Institute of Chemical Engineers, National Meeting, 54th, Las Vegas, Nev., Sept. 20-23, 1964, Paper.)

Chemical Engineering Progress, Symposium Series, no. 61, 1966, p. 7-13. 8 refs.

Contract No. DA-01-021-ORD-11878(z).

Investigation of mathematical models of the curing process to obtain a solution to the curing problem of highly exothermic propellants. General digital-computer programs were developed to permit a detailed analysis of heat conduction coupled to a chemical reaction in grains with a circular or any regular star perforation. To ensure correspondence between the model and the physical problem, a complementary experimental program was undertaken. Special test methods were developed to determine thermal properties. Procedures were developed for determining curing kinetics from temperature histories in an adiabatic calorimeter and from isothermal dilatometric data. Predictions of curing phenomena were made using the mathematical models with experimental data for a typical propellant. M.M.

A66-39869

CONTINUOUS PNEUMATIC MIXING.

A. J. Colli (U.S. Naval Propellant Plant, Indian Head, Md.).

(Chemical Engineering Progress, vol. 60, Oct. 1964, p. 81-84.)

Chemical Engineering Progress, Symposium Series, no. 61, 1966, p. 14-18.

A66-39870

ECONOMIC SELECTION OF COMPOSITE PROPELLANT MANUFACTURING TECHNIQUES OF THE NEAR FUTURE.

D. C. McGehee and P. K. Myers (Aerojet-General Corp., Sacramento, Calif.).

(American Institute of Chemical Engineers, National Meeting, 54th, Las Vegas, Nev., Sept. 20-23, 1964, Papers.)

Chemical Engineering Progress, Symposium Series, no. 61, 1966, p. 19-28

Discussion of the type of future processing which will be used to produce castable composite high-energy propellants as economically as possible. Based on economic studies, castable composite

propellant processing plants constructed during the next five years will be designed around either multiple 300-gal batch vertical change-can mixers or large single continuous propellant mixers. In general, continuous processing offers increasingly attractive cost advantages over any batch technique as rates exceed one million lb per month. Batch mixing is most economical at lower rates where several different propellant systems must be handled each week. Raw material costs are the most important single cost factor in determining the total cost of propellant ready for rocket loading.
M. M.

A66-39871
ROLE OF HETEROGENEOUS REACTIONS IN IGNITION OF COMPOSITE SOLID PROPELLANTS.
Ralph Anderson, R. S. Brown, and L. J. Shannon (United Aircraft Corp., United Technology Center Div., Sunnyvale, Calif.).
(American Institute of Chemical Engineers, National Meeting, 54th, Las Vegas, Nev., Sept. 20-23, 1964, Paper.)
Chemical Engineering Progress, Symposium Series, no. 61, 1966, p. 29-43. 14 refs.

Demonstration that hypergolic ignition of composite solid propellants through contact with chemically reactive gaseous or liquid oxidizers proceeds through the development of heterogeneous chemical reactions at the interface between the oxidizer fluid and the solid propellant. The applicability of the heterogeneous reaction concept for both moderately reactive and highly reactive oxidizers is established by the ability of the mathematical model of the hypergolic ignition process to predict quantitatively the experimentally observed effects of environmental oxidizer concentration, pressure, temperature, and heat flux on the ignition delay of solid propellants in both static and highly turbulent flow environments. A combination of the heterogeneous reaction concept with solid oxidizer decomposition data shows that the response of the composite propellant to any ignition stimulus is controlled to a large degree by exothermic heterogeneous reactions on and within the propellant surface. When the rate of heat released by these reactions between solid oxidizer decomposition products and adjacent binder becomes sufficiently high, the propellant seeks steady-state combustion conditions without additional energy transfer from the igniter. Based on these concepts, a qualitative model of the response of solid propellants to an ignition stimulus has been developed. The model accounts for the observed effects on the propellant ignition delay time of such variables as heat flux, environmental pressure, initial temperature, propellant formulation variables, and propellant mechanical properties. (Author)

A66-39874
PROPELLANT DEFLAGRATION CONTROL - A METHOD FOR SUPPRESSING UNSTABLE COMBUSTION.
L. A. Dickinson, E. L. Capener, and R. J. Kier (Stanford Research Institute, Menlo Park, Calif.).
(American Institute of Chemical Engineers, National Meeting, 54th, Las Vegas, Nev., Sept. 20-23, 1964, Paper.)
Chemical Engineering Progress, Symposium Series, no. 61, 1966, p. 63-69.
Contract No. AF 49(638)-565.

Because certain correlations between propellant and instability were observed, it is argued that the instability might be controlled by reactions occurring at or near the burning surface. Results of experimental studies suggested by this hypothesis indicate that this control is an effective way of precluding a regenerative interaction between a fluid dynamic disturbance and the propellant combustion reaction. (Author)

A66-39876
HYDRODYNAMIC FACTORS INFLUENCING THE COMBUSTION OF HYBRID PROPULSION SYSTEMS.
L. J. Hurt and S. E. Anderson (Rohm and Haas Co., Huntsville, Ala.).
(American Institute of Chemical Engineers, National Meeting, 56th, Symposium on the Technology of Hybrid Rockets, San Francisco, Calif., May 16-19, 1965, Preprint 34b.)
Chemical Engineering Progress, Symposium Series, no. 61, 1966, p. 78-85. 13 refs.
Contract No. DA-01-021-ORD-11878(z).

A66-39878
AN EXPERIMENTAL INVESTIGATION OF A LITHIUM ALUMINUM HYDRIDE - HYDROGEN PEROXIDE HYBRID ROCKET.
Ronald V. Osmon (Northrop Corp., Norair Div., Hawthorne, Calif.).
(American Institute of Chemical Engineers, National Meeting, 56th, Symposium on the Technology of Hybrid Rockets, San Francisco, Calif., May 16-19, 1965, Preprint 34d.)
Chemical Engineering Progress, Symposium Series, no. 61, 1966, p. 92-102. 9 refs.

A66-39880
IGNITION AND COMBUSTION CHARACTERISTICS OF LIQUID OXYGEN AND LIQUID METHANE MIXTURES.
James O. Thieme and Richard L. Every (Continental Oil Co., Ponca City, Okla.).
(American Institute of Chemical Engineers, National Meeting, 56th, San Francisco, Calif., May 16-19, 1965, Preprint 28e.)
Chemical Engineering Progress, Symposium Series, no. 61, 1966, p. 113-117.

This paper presents the results of a study necessary to evaluate the possibility of using liquid oxygen-liquid methane mixture as rocket monopropellants. The experiments were designed to determine the ignition and controlled burning feasibility of these fuel and oxidizer mixtures. Results of these tests show that liquid oxygen-liquid methane mixtures can be burned under certain conditions. These conditions are presented as well as less favorable conditions where detonation can be expected to occur. Photographs of the damage incurred from an unexpected detonation are also included. (Author)

A66-39882
KINETICALLY LIMITED PERFORMANCE OF THE HYDROGEN-FLUORINE PROPELLANT SYSTEM.
W. G. Burwell, V. J. Sarli, and T. F. Zupnik (United Aircraft Corp., East Hartford, Conn.).
(American Institute of Chemical Engineers, National Meeting, 56th, San Francisco, Calif., May 16-19, 1965, Preprint 28a.)
Chemical Engineering Progress, Symposium Series, no. 61, 1966, p. 125-135. 19 refs.

Brief review of analytical methods for determining nonequilibrium dissociation losses in high-energy rocket propellants. Results are shown for the hydrogen-fluorine propellant system. These results indicate which of the many possible hydrogen-fluorine recombination steps are rate-controlling over a range of combustion-chamber pressures and mixture ratios, and hence which are responsible for the chemical nonequilibrium performance degradation. The sensitivity of this degradation to possible errors in the kinetic rate data used is demonstrated. M. M.

A66-39887
ZERO GRAVITY STABILITY TESTING OF A LIQUID-FILLED SPACE VEHICLE.
Gordon S. Reiter and David A. Lee (TRW, Inc., TRW Systems Group, Redondo Beach, Calif.).
(American Institute of Chemical Engineers, National Meeting, 55th, Symposium on Effects of Zero Gravity on Fluid Dynamics and Heat Transfer - Part I, Houston, Tex., Feb. 7-11, 1965, Preprint 17c.)
Chemical Engineering Progress, Symposium Series, no. 61, 1966, p. 178-183.

A66-39889
THERMAL-MECHANICAL ENVIRONMENTAL EXPERIMENTS ON FLIGHT TYPES OF INSULATION SYSTEMS FOR SPACE CRYOGENIC STORAGE TANKS.
J. W. Anderson and C. F. Merlet (Lockheed Aircraft Corp., Lockheed Missiles and Space Co., Sunnyvale, Calif.).
(American Institute of Chemical Engineers, National Meeting, 56th, Symposium on Cryogenic Engineering in the Aerospace Industry, San Francisco, Calif., May 16-19, 1965, Preprint 22f.)
Chemical Engineering Progress, Symposium Series, no. 61, 1966, p. 193-199.
[For abstract see issue 12, page 1775, Accession no. A65-22495]

A66-39893
THERMAL CONDUCTIVITY OF WET-WALL LIQUID HYDROGEN STORAGE TANK INSULATIONS FOR SPACE APPLICATIONS.
Andrew C. Rawuka and Charles G. Yundt (Douglas Aircraft Co., Inc., Santa Monica, Calif.).
(American Institute of Chemical Engineers, National Meeting, 56th, Symposium on Cryogenic Engineering in the Aerospace Industry, San Francisco, Calif., May 16-19, 1965, Preprint 22d.)
Chemical Engineering Progress, Symposium Series, no. 61, 1966, p. 219-224. 6 refs.
[For abstract see issue 12, page 1775, Accession no. A65-22460]

A66-39895
THE ON-SITE MANUFACTURE OF PROPELLANT OXYGEN FROM LUNAR RESOURCES.
Sanders D. Rosenberg, Gerald A. Guter, and Frederick E. Miller (Aerojet-General Corp., Azusa, Calif.).
(American Institute of Chemical Engineers, Annual Meeting, 57th, Symposium on Chemical Processing in Extraterrestrial Environments, Boston, Mass., Dec. 6-10, 1964, Preprint 46c.)
Chemical Engineering Progress, Symposium Series, no. 61, 1966, p. 228-234.

A66-40226 #
SMALL LIQUID PROPULSION SYSTEMS TESTING IN A SPACE ENVIRONMENT SIMULATOR.
T. E. Mouritsen (LTV Aerospace Corp., LTV Astronautics Div., Dallas, Tex.) and C. E. Sullivan (LTV Aerospace Corp., LTV Astronautics Div., Engineering Laboratories Section, Dallas, Tex.).
IN: AMERICAN INSTITUTE OF AERONAUTICS AND ASTRONAUTICS, INSTITUTE OF ENVIRONMENTAL SCIENCES, AND AMERICAN SOCIETY FOR TESTING AND MATERIALS, SPACE SIMULATION CONFERENCE, HOUSTON, TEX., SEPTEMBER 7-9, 1966. TECHNICAL PAPERS. [A66-40204 22-11]
New York, American Institute of Aeronautics and Astronautics, 1966, p. 166-171.

Small liquid propulsion systems have been successfully tested in a space environment simulator chamber of high vacuum capability and low throughput pumping capacity. Testing of these small liquid propulsion systems (1 to 5-lb thrust) at low temperatures and pressures is required to support the analysis, design, and development of such systems for space applications. The existing pumping capabilities and the storage capacity within the chamber were analyzed over a range of pressures for matching with the mass flow requirements of the rocket thrusters. Permissible rocket motor operating parameters within this chamber were established by selecting rocket motor pulse lengths to stay within diffusion pump backstreaming pressure limits and rocket nozzle expanded nozzle conditions. Tests have been successfully conducted. Included are tests for a Scout vehicle, an H_2O_2 reaction control system, hydrogen peroxide 2-lb motor plume heating with extravehicular space suit materials, Astronaut Maneuvering Unit hydrogen peroxide motor development performance and plume impingement, hydrogen peroxide 2.3-lb thrust motor for space structure plume interaction, and hydrazine 2-lb thrust motor performance and exhaust plume investigation. (Author)

A66-40237 #
IGNITION OF HYPERGOLIC PROPELLANTS AT LOW PRESSURE AND LOW TEMPERATURE IN A SPACE ENVIRONMENT SIMULATION CHAMBER.
R. L. Chuan and P. C. Wilber (Celestial Research Corp., South Pasadena, Calif.).
IN: AMERICAN INSTITUTE OF AERONAUTICS AND ASTRONAUTICS, INSTITUTE OF ENVIRONMENTAL SCIENCES, AND AMERICAN SOCIETY FOR TESTING AND MATERIALS, SPACE SIMULATION CONFERENCE, HOUSTON, TEX., SEPTEMBER 7-9, 1966. TECHNICAL PAPERS. [A66-40204 22-11]
New York, American Institute of Aeronautics and Astronautics, 1966, p. 236-241. 6 refs.

Experimental and theoretical investigation of hydrazine-nitrogen tetroxide-type systems. The experimental program was designed around three subscale systems in order to predict safe operational limits for a full size facility with reasonable confidence. The largest of the systems consisted of a 56-in. sphere of 304 stainless steel latitudinally divided into five separately controlled thermal zones with a controllable temperature range from liquid-nitrogen temperature to ambient. General conclusions regarding reaction characteristics are given, and gas phase reactions in two systems are outlined. Warmup and defrost of a space chamber and condensate removal techniques are discussed. B.B.

A66-40352 #
INFLUENCE OF COMBUSTION PARAMETERS ON INSTABILITY IN SOLID PROPELLANT MOTORS. I - DEVELOPMENT OF MODEL AND LINEAR ANALYSIS.
John C. Friedly and Eugene E. Petersen (California, University, Berkeley, Calif.).
AIAA Journal, vol. 4, Sept. 1966, p. 1604-1610.

A model is developed for the unsteady-state combustion of a solid propellant subject to acoustic pressure oscillations in the intermediate frequency range. The solution for perturbations is obtained and arranged in a matrix form which can be conveniently altered to accommodate model modifications. The acoustic admittance calculated from the model is found to depend strongly on only four parameters, the activation energies of a surface reaction and the flame reaction, the order of the flame reaction, and the surface temperature. A relationship is found between the frequency at which the maximum in the acoustic admittance occurs and the surface temperature and the surface activation energy. (Author)

A66-40355 #
NONACOUSTIC INSTABILITY OF COMPOSITE PROPELLANT COMBUSTION.
M. W. Beckstead (U.S. Naval Ordnance Test Station, Aerothermochemistry Group, China Lake, Calif.), N. W. Ryan, and A. D. Baer (Utah, University, Dept. of Chemical Engineering, Salt Lake City, Utah).
(American Institute of Aeronautics and Astronautics, Aerospace Sciences Meeting, 3rd, New York, N.Y., Jan. 24-26, 1966, Paper 66-111.)
AIAA Journal, vol. 4, Sept. 1966, p. 1622-1628. 20 refs.
Grant No. AF AFOSR 446-63.

A66-40356 #
A MODEL OF COMPOSITE PROPELLANT COMBUSTION INCLUDING SURFACE HETEROGENEITY AND HEAT GENERATION.
Clarke E. Hermance (Waterloo, University, Dept. of Mechanical Engineering, Waterloo, Ontario, Canada).
(American Institute of Aeronautics and Astronautics, Aerospace Sciences Meeting, 3rd, New York, N.Y., Jan. 24-26, 1966, Paper 66-112.)
AIAA Journal, vol. 4, Sept. 1966, p. 1629-1637. 17 refs.
Research sponsored by the Aeronautical Research Institute of Sweden.

A66-40361 #
NONLINEAR MECHANICAL MODEL FOR THE DESCRIPTION OF PROPELLANT SLOSHING.
Helmut F. Bauer (Georgia Institute of Technology, School of Engineering Mechanics, Atlanta, Ga.).
AIAA Journal, vol. 4, Sept. 1966, p. 1662-1668. 8 refs.
Contract No. NAS 8-11159.

Shortly before resonance, the liquid with a free surface in a laterally oscillating container ceases to oscillate about its nodal diameter. The stable planar motion of the liquid shifts into an erratic fluid surface motion, i.e., an unstable motion for which the motion of the modal diameter changes constantly. At a further small increase of the forcing frequency, a stable nonplanar motion occurs. The present paper attempts to describe the planar and "rotary" sloshing motion of the liquid by a simple analytical mechanical model that consists of a mass point constraint to a parabolic surface. It is connected to a nonlinear spring. It was found that the change of two system parameters and a third-order nonlinear spring describes the liquid motion in a cylindrical container. Test results agree very well with the analytical data. (Author)

A66-40507 #
TOXICITY OF UNSYMMETRICAL DIMETHYLHYDRAZINE (UDMH) [SULLA TOSSICITA' DELLA DIMETILIDRAZINA ASIMMETRICA].
Gualtiero Paolucci.
Rivista di Medicina Aeronautica e Spaziale, vol. 29, Apr.-June 1966, p. 305-328. 9 refs. In Italian.

Discussion of investigations performed since 1962 in the field of the toxicity of UDMH. It was found that UDMH does not cause any trouble or anatomo-pathologic changes at low dosage because the substance does not accumulate in the body. Large dosages, however, will cause convulsion and death due to respiratory paralysis; fatty degeneration was reported at these dosages, particularly in the liver and kidney. Regarding metabolism UDMH increases blood sugar level and causes moderate hematocrit changes, as well as some increase in glutamic-oxalacetic transaminase. Pyridoxine (together with a few other compounds) was found useful in combatting the toxic effects of this substance, at a dose of 50 mg/kg of body weight. M. M.

A66-41218
ADVANCED PROPELLANT CHEMISTRY; AMERICAN CHEMICAL SOCIETY, MEETING, 149TH, DETROIT, MICH., APRIL 6, 7, 1965, PAPERS.
Symposium sponsored by the Division of Fuel Chemistry of the American Chemical Society and the Propellants and Combustion Technical Committee of the American Institute of Aeronautics and Astronautics.
Washington, D.C., American Chemical Society (Advances in Chemistry Series No. 54), 1966. 290 p.
$8.50.

CONTENTS:

PHYSICAL PROPERTIES OF THE LIQUID OZONE-FLUORINE SYSTEM. A. J. Gaynor and Charles K. Hersh (Illinois Institute of Technology, Chicago, Ill.), p. 279-285. [See A66-41244 23-27]
INDEX, p. 287-290.

A66-41225
THE DEFLAGRATION OF HYDRAZINE PERCHLORATE.
J. B. Levy, G. Von Elbe, R. Friedman, T. Wallin, and S. J. Adams (Atlantic Research Corp., Alexandria, Va.).
IN: ADVANCED PROPELLANT CHEMISTRY; AMERICAN CHEMICAL SOCIETY, MEETING, 149TH, DETROIT, MICH., APRIL 6, 7, 1965, PAPERS. [A66-41218 23-27]
Symposium sponsored by the Division of Fuel Chemistry of the American Chemical Society and the Propellants and Combustion Technical Committee of the American Institute of Aeronautics and Astronautics.
Washington, D.C., American Chemical Society (Advances in Chemistry Series No. 54), 1966, p. 55-72. 22 refs.
Contract No. AF 49(638)-1169.

The deflagration of hydrazine perchlorate, both pure and with fuel and catalyst additives, has been investigated. Hydrazine perchlorate will deflagrate reproducibly if a few-percent fuel is present. The deflagration process is catalyzed by copper chromite, potassium dichromate, and magnesium oxide. Deflagration rates have been measured photographically from 0.26 to 7.7 atm. A liquid layer was observed at the surface in these experiments. Vaporization rate measurements from 180 to 235°C have yielded the expression $\log_{10}P_{(mm)} = 10.2 - 6400/T$ for the vapor pressure of hydrazine perchlorate. Temperature profiles of the deflagration wave have been measured, and spectroscopic measurements of the flame temperature above a deflagrating strand have been made. The results are discussed in terms of the mechanism of deflagration of hydrazine perchlorate. (Author)

A66-41226
THERMAL DECOMPOSITION OF HYDRAZINIUM MONOPERCHLORATE AND HYDRAZINIUM DIPERCHLORATE.
Chester J. Grelecki and William Cruice (Thiokol Chemical Corp., Reaction Motors Div., Denville, N.J.).
IN: ADVANCED PROPELLANT CHEMISTRY; AMERICAN CHEMICAL SOCIETY, MEETING, 149TH, DETROIT, MICH., APRIL 6, 7, 1965, PAPERS. [A66-41218 23-27]
Symposium sponsored by the Division of Fuel Chemistry of the American Chemical Society and the Propellants and Combustion Technical Committee of the American Institute of Aeronautics and Astronautics.
Washington, D.C., American Chemical Society (Advances in Chemistry Series No. 54), 1966, p. 73-81. 6 refs.
Contracts No. AF 04(694)-334; No. Nonr-4364(00).

A manometric technique was used to measure the rate of pressure rise, which in turn is a measure of the rate of formation of volatile products produced during the thermal decomposition of hydrazinium monoperchlorate and hydrazinium diperchlorate. Kinetic expressions were developed, temperature coefficients were determined, and an attempt was made to interpret these in terms of current theories of reaction kinetics. The common rate-controlling step in each case appears to be the decomposition of perchloric acid into active oxidizing species. The reaction rate is proportional to the amount of free perchloric acid or its decomposition products which are present. In addition the temperature coefficients are similar for each oxidizer and are equivalent to that of anhydrous perchloric acid. (Author)

A66-41227
DECOMPOSITION OF NITRONIUM PERCHLORATE.
M. D. Marshall and L. L. Lewis (Callery Chemical Co., Callery, Pa.).
IN: ADVANCED PROPELLANT CHEMISTRY; AMERICAN CHEMICAL SOCIETY, MEETING, 149TH, DETROIT, MICH., APRIL 6, 7, 1965, PAPERS. [A66-41218 23-27]
Symposium sponsored by the Division of Fuel Chemistry of the American Chemical Society and the Propellants and Combustion Technical Committee of the American Institute of Aeronautics and Astronautics.
Washington, D.C., American Chemical Society (Advances in Chemistry Series No. 54), 1966, p. 82-92. 13 refs.
Contract No. DA-31-124-ARO(D)-12.

Experimental study of the decomposition of nitronium perchlorate. The decomposition reaction for nitronium perchlorate is believed to involve the formation of nitrosonium perchlorate and oxygen. The other products (NO_2, Cl_2, ClO_2) observed during the decomposition are thought to be the result of the subsequent decomposition of nitrosonium perchlorate. This mechanism is clearly demonstrated in vacuo by a preponderance of oxygen in the volatiles during the early stages of the decomposition of nitronium perchlorate in vacuo and by the products of the latter stages which describe the decomposition of nitrosonium perchlorate. It is found that in sealed tubes the reaction of dinitrogen tetroxide with nitronium perchlorate ultimately predominates, giving nitrosonium perchlorate and oxygen as products. It is noted that this reaction is catalyzed by dinitrogen tetroxide. A.B.K.

A66-41228
ADVANCED BINDERS FOR SOLID PROPELLANTS - A REVIEW.
Murray S. Cohen (Thiokol Chemical Corp., Reaction Motors Div., Denville, N.J.).
IN: ADVANCED PROPELLANT CHEMISTRY; AMERICAN CHEMICAL SOCIETY, MEETING, 149TH, DETROIT, MICH., APRIL 6, 7, 1965, PAPERS. [A66-41218 23-27]
Symposium sponsored by the Division of Fuel Chemistry of the American Chemical Society and the Propellants and Combustion Technical Committee of the American Institute of Aeronautics and Astronautics.
Washington, D.C., American Chemical Society (Advances in Chemistry Series No. 54), 1966, p. 93-107. 22 refs.

Review of the polymer chemistry associated with the development of binders for solid propellants. Binder development is traced from its beginnings in early asphalt systems to polymeric systems with random cure sites and polymeric systems with end-group cure sites. Attempts to introduce oxidants into the binder structure in the form of nitrato, nitro, perchlorate, and difluoramine groups are described, as well as the results of studies of fluorocarbon polymers. Work on fuel binders and on decaborane, carborane, and aluminum hydride-derived polymers is discussed. A.B.K.

A66-42240 #
METHANE-FUELED PROPULSION SYSTEMS.
Richard J. Weber (NASA, Lewis Research Center, Mission Analysis Branch, Cleveland, Ohio), James F. Dugan, Jr. (NASA, Lewis Research Center, Propulsion Section, Cleveland, Ohio), and Roger W. Luidens (NASA, Lewis Research Center, Flight Systems Section, Cleveland, Ohio).
Astronautics and Aeronautics, vol. 4, Oct. 1966, p. 48-55. 7 refs.

Review of the advantages of liquid methane as a fuel for a representative SST configuration. The prime interest of methane lies in its heat of combustion, which is 16% higher than JP or kerosene. It is also superior in cooling capacity and might cost less. In spite of the low density of methane, it is considered that its advantages could improve the payload and the direct operating cost of an SST by approximately 30%. F.R.L.

A66-42695
HYBRID ROCKET PROPULSION.
André Moutet (ONERA, Châtillon-sous-Bagneux, Seine, France).
IN: UNMANNED EXPLORATION OF THE SOLAR SYSTEM; AMERICAN ASTRONAUTICAL SOCIETY, SYMPOSIUM ON UNMANNED EXPLORATION OF THE SOLAR SYSTEM, DENVER, COLO., FEBRUARY 8-10, 1965, PROCEEDINGS. [A66-42653 24-30]
Edited by G. W. Morgenthaler and R. G. Morra.
Baltimore, American Astronautical Society; North Hollywood, Calif., Western Periodicals Co. (Advances in the Astronautical Sciences. Volume 19), 1965, p. 911-931.

Investigation of the use of hybrid rockets using a solid fuel and a liquid or gaseous oxidizer. Three methods of making experimental determinations of ablation velocity are described, and rocket motor working conditions, combustion instabilities, and ignition lag are discussed. Finally, some examples of test bench and other types of engine designs are evaluated. B.B.

A66-80827
RENAL FUNCTIONAL RESPONSE TO HYDRAZINE AND 1,1-DIMETHYLHYDRAZINE.
Edward T. Wong (USAF School of Aerospace Med., Brooks AFB, Tex.)
Toxicology and Applied Pharmacology, vol. 8, Jan. 1966, p. 51-56. 6 refs.
Alterations in renal function were determined in dogs after an acute exposure to hydrazine or to unsymmetrical 1,1-dimethylhydrazine (UDMH). In the control group, the creatinine clearances and Tm_G (maximal rate of tubular resorption ofg glucose) remained relatively constant despite prolonged hyperglycemia. Creatinine clearance and Tm_G showed a prompt fall within minutes after hydrazine injection (20 mg./kg.), and continued to fall throughout the period of observation (240 min.). After UDMH (45 mg./kg.), Tm_G did not differ from the values of the control group; but creatinine clearance showed a slight but statistically significant increase. Both drugs produced increased salivation, hyperventilation, occasional vomiting and diarrhea, and increased neuromuscular activity. The reduction in creatinine clearance and Tm_G indicate that hydrazine produces a decreased glomerular filtration rate and an impairment in proximal renal tubular function. It seems safe to assume that UDMH (at 45 mg./kg.) does not produce a deleterious change in renal function.

A66-80867
RADIOPROTECTIVE AGENTS DERIVED FROM THIOGLYCOLLIC ACID.
F. L. Rose and A. L. Walpole (Imp. Chem. Ind. Ltd., Pharm. Div., Alderley Park, Macclesfield, Great Britain).
(First Intern. Symp. on Radiosensitizers and Radioprotective Drugs, Milan, 1964).
Progress in Biochemical Pharmacology, vol. 1, 1965, p. 432-441.
Thioglycollic hydrazide, which contains the skeleton common to several other radioprotective agents, was investigated in the form of four closely related but more stable derivatives. N-acetylthioglycollic hydrazide was less effective than N_1:N^4-diacetyldithioglycollic dihydrazide in protecting mice against the lethal action of mustard gas, but the two compounds, given intraperitoneally in the same fraction of their respective median lethal doses, produced about the same increase in the LD_{50} of whole-body X-irradiation (from 655 rads to 895 and 880 rads, respectively).

A66-81044
EXPOSURE CRITERIA FOR FLUORINE ROCKET PROPELLANTS.
Peter M. Ricca (NASA, John F. Kennedy Space Center, Cape Kennedy, Fla.)
(Fourth Inter-Am. Conf. on Toxicol. and Occupational Med., Miami, Fla., Aug. 24-27, 1964).
Archives of Environmental Health, vol. 12, Mar. 1966, p. 399-407. 13 refs.
Space vehicles currently being developed use liquid fluorine (LF_2) as well as liquid fluorine and oxygen mixtures (FLOX), which generally cannot be totally contained even in closed, zero-loss handling systems. Releases into the atmosphere usually involve fluorine/hydrogen fluoride (F_2/HF) mixtures, both of which cause irritation of epithelial tissues, especially of the eyes and respiratory tract in low concentrations and irreversible detrimental effects to health at high concentrations. The chemical and physical properties, and the physiological and toxicological effects of both substances are outlined. In previous animal studies, fluorine was more toxic than HF in both tolerance thresholds and species susceptibility. Two toxicity guidelines have been used in the aerospace industry: Emergency Tolerance Limit (ETL) and Emergency Exposure Limit (EEL). The limits differ only in the degree of risk accepted. The assumptions on which the EEL and ETL are based are summarized. In humans, short-term exposures to fluorine at 20 mg./m.^{3} for five minutes should not cause irreparable respiratory damage, and 5 mg./m.^{3} for short single exposures should be tolerable from a comfort standpoint.

A66-81213
EMERGENCY EXPOSURE LIMITS.
J. P. Frawley, K. H. Jacobson, J. C. Calandra, W. G. Fredrick, D. B. Hood, M. L. Keplinger, E. D. Palmes, H. E. Stokinger, T. R. Torkelson, J. F. Treon, M. H. Weeks, C. S. Weil, and N. G. White.
American Industrial Hygiene Association Journal, vol. 27, Mar.-Apr. 1966, p. 193-195. 16 refs.
Emergency limits for human exposure to pentaborane-9 are listed as: 25 p.p.m. (65 mg./m.^{3}), 5 min.; 8 p.p.m. (21 mg./m.^{3}), 15 min.; 4 p.p.m. (10 mg./m.^{3}), 30 min.; 2 p.p.m. (5 mg./m.^{3}), 60 min. Exposure for one min. at 1000 p.p.m. causes convulsions in many, and death in a few men. The onset of symptoms after borane exposure varies from immediate to 24-hr. delay. Initial symptoms are lightheadedness, drowsiness, headache, severe fatigue, or muscle spasms.

A66-81233
MILITARY AND SPACE SHORT-TERM INHALATION STANDARDS.
Henry F. Smyth, Jr. (Mellon Inst., Pittsburgh, Pa.)
(Ind. Hyg. Found., 30th Ann. Meeting, Pittsburgh, Oct. 20-21, 1965).
Archives of Environmental Health, vol. 12, Apr. 1966, p. 488-490.
The short-term inhalation standards which the National Academy of Sciences—National Research Council Committee on Toxicology has recommended for the guidance of military and space agencies are presented. The contaminants involved include oxygen difluoride, fluorine, monomethyl hydrazine, hydrogen fluoride, hydrogen chloride, nitrogen dioxide, sulfur dioxide, unsymmetrical dimethyl hydrazine, carbon disulfide, hydrogen sulfide, and carbon monoxide. These standards are designated Emergency Exposure Limits, the same designation applied to the American Industrial Hygiene Association standards. The concepts of the two sets of standards appear to be essentially identical. In most instances the numerical values are identical. They are intended to be applied to planning operating conditions so that an accident which may occur at an unpredictable time cannot expose a worker to a dangerous concentration. They are not appropriate for exposures which are certain to occur at predictable times.

A67-10211
COMPATIBILITY OF METALLIC MATERIALS WITH MEDIUM-ENERGY HYPERGOLIC ROCKET PROPELLANTS [VERTRÄGLICHKEIT METALLISCHER WERKSTOFFE MIT MITTELENERGETISCHEN, HYPERGOLEN RAKETENTREIBSTOFFEN].
H. Meier zu Köcker (Entwicklungsring Nord GmbH, Bremen; Aachen, Technische Hochschule, Institut für Brennstoffchemie, Aachen, West Germany) and H. Weitzig (Entwicklungsring Nord GmbH, Bremen, West Germany).
Luftfahrttechnik Raumfahrttechnik, vol. 12, Sept. 1966, p. 233-237. In German.
Discussion of experience acquired in the development of the ELDO rocket concerning the compatibility of metals with the hypergolic propellant components hydrazine/UDMH and N_2O_4. Compatibility results are tabulated for propellant tanks, tubing, pressure-reducing valves, and other control devices, including simulation and vacuum chambers. V.P.

A67-10602
LUBRICITY OF JET FUELS.
J. K. Appeldoorn and W. G. Dukek (Esso Research and Engineering Co., Linden, N.J.).
Society of Automotive Engineers, Aeronautic and Space Engineering and Manufacturing Meeting, Los Angeles, Calif., Oct. 3-7, 1966, Paper 660712. 12 p. 18 refs.
Contract No. AF 33(615)-2828.
Comment on the fact that the poor performance of some high purity jet fuels appears to be related to polar compounds in the fuel and not to viscosity, volatility, or sulfur and nitrogen compounds. Surface active additives such as corrosion inhibitors markedly improve lubricity. Results of laboratory tests correlate well with the field experience, where sticking fuel controls and pump wear at high temperatures have been reported. Highly refined fuels developed to meet new standards of thermal stability or purity are generally poor in lubricity compared with conventionally refined fuels and may require lubricity additive to satisfy advanced fuel systems. (Author)

A67-10639 #
FUELS FOR SPACE TRAVEL [BRENNSTOFFELEMENTE FÜR DIE RAUMFAHRT].

Hans Swart.
Astronomie und Raumfahrt, no. 3, 1966, p. 90-96. 8 refs. In German.

Review of the characteristics of the elements and compounds which are used in the construction of fuel cells, and a description of the fuel cell system used aboard the Gemini GT-5 space capsule. The general principles of fuel cell operation and the oxidation potentials of such substances as hydrazine are considered. The data for the performance capabilities of H_2/O_2, N_2H_4/O_2, methanol/air, and amalgam/O_2 combinations are compared. The design and construction used for the Gemini fuel cells are described; these cells consumed about 0.4 kg of hydrogen and oxygen per kw of electrical energy produced. D.P.F.

A67-11147
THE REACTION OF IMINES WITH DIFLUORAMINE - A METHOD OF PREPARATION OF DIAZIRINES.
W. H. Graham (Rohm and Haas Co., Redstone Research Laboratories, Huntsville, Ala.).
American Chemical Society, Journal, vol. 88, Oct. 20, 1966, p. 4677-4681. 22 refs.
Contract No. DA-01-021-AMC-11536(Z).

Investigation of the reaction of various imines with difluoramine. This reaction gives a variety of products, of three type compounds: (1) diazirines, (2) α-haloazo compounds, and (3) α-fluoroalkylidene-hydrazines. The relative ratios of the products depend on the structure of the imine. The principal products identified and their yield and pertinent physical data are tabulated. The different reactions tested and their results are described. Some of the compounds obtained may have potential applications as missile propellant components. W.A.E.

A67-11386 * #
SOME DIFFICULTIES OF OPERATING LIQUID SYSTEMS IN A VACUUM.
John A. Simmons and Ralph D. Gift (Atlantic Research Corp., Alexandria, Va.).
International Astronautical Federation, International Astronautical Congress, 17th, Madrid, Spain, Oct. 9-15, 1966, Paper. 10 p.
NASA-sponsored research.

Discussion emphasizing some potential difficulties of operating liquid propulsion systems in space. Boiling, evaporation, cooling, and freezing - which result when a liquid is exposed to a vacuum - lead to several types of operational difficulties for liquid systems in space. Some operational difficulties that may be caused by these phenomena were demonstrated in three sets of experiments. The results of these experiments demonstrate three criteria for plug formation and stoppage of flow. First, in most circumstances, the flow must be intermittent to allow growth of a plug. A second criterion for plug formation is that there be some protuberance or roughness of the surface which can be grasped by the frozen material and thereby provide support for the plug. A third criterion is that evaporative cooling be sufficient to maintain the juncture of the plug and the vent line at or below the freezing point of the liquid. M.F.

A67-11420 #
EXPERIMENTAL DETERMINATION OF THE BURNING RATE IN HYBRID PROPELLANTS BY USING A RADIOACTIVE SOURCE [DETERMINACION EXPERIMENTAL DE LA VELOCIDAD DE REGRESION EN LOS PROPERGOLES HIBRIDOS EMPLEANDO UNA FUENTE RADIACTIVA].
Alberto Calvet and Manuel Villena (Tarrasa, Escuela Técnica Superior de Ingenieros Industriales, Cátedra de Motores, Laboratorio de Tecnologia de la Propulsion, Tarrasa, Spain).
International Astronautical Federation, International Astronautical Congress, 17th, Madrid, Spain, Oct. 9-15, 1966, Paper. 6 p. In Spanish.

Analysis of the possibilities offered by radioisotopes to obtain desired measurements of the burning rate of a hybrid propellant. An external gamma emission source is recommended which is located outside the motor, diametrically opposite to a detector. Transmission measurements are made, and the attenuation of the radiation varies during the time of combustion. F.R.L.

A67-11435 #
DYNAMIC ANALYSIS OF THE REACTION CONTROL ROCKET ENGINES AND PROPELLANT SYSTEM OF THE LUNAR MODULE USING DIGITAL COMPUTER METHODS.
Robert C. Bowlin, Robert K. Rose (General Electric Co., Research and Development Center, Schenectady, N.Y.), and Douglas W. Sedgley (Grumman Aircraft Engineering Corp., Bethpage, N.Y.).
International Astronautical Federation, International Astronautical Congress, 17th, Madrid, Spain, Oct. 9-15, 1966, Paper. 13 p.

Dynamic analysis of the reaction control system (RCS) propellant feed network on the lunar module using digital computer techniques. Complex hydraulic feed networks are analyzed using graphical or analog computer methods, although it is estimated that the problem under consideration would require an analog computer capability beyond 500 amplifiers. Because of the modular approach used, the program is said to be readily adaptable to various systems and engine designs, and its use is planned for future space vehicle systems. B.B.

A67-11450 #
AN AEROTHERMOCHEMICAL ANALYSIS OF SOLID PROPELLANT COMBUSTION.
T. Paul Torda (Illinois Institute of Technology, Chicago, Ill.) and Frederick L. Schuyler (General Electric Co., King of Prussia, Pa.).
International Astronautical Federation, International Astronautical Congress, 17th, Madrid, Spain, Oct. 9-15, 1966, Paper. 12 p. 6 refs.
USAF-supported research.

Steady state combustion of solid propellant rockets has been investigated theoretically. The purpose of the investigation was to eliminate some of the simplifications that have been employed in previous analyses. A mathematical model was formulated which is representative of the combustion of mono- and double-base propellants in which laminar flow is assumed. Through boundary conditions, the nonlinear differential equations describing the motion of a two-dimensional, compressible, chemically reacting fluid were coupled with the one-dimensional heat conduction equation of a burning solid propellant. The FORTRAN IV language and an IBM 7040 digital computer were used to solve six problems for which solutions have been previously published. The solutions using the present method reproduced, usually within 0.5%, the published results. Computations using realistic rocket conditions as input yielded results of propellant burning rate and wall temperature that fall within the range of previously obtained experimental values. (Author)

A67-11947 ±
SPIN EFFECTS ON ROCKET NOZZLE PERFORMANCE.
Leo J. Manda (Emerson Electric Co., Electronics and Space Div., St. Louis, Mo.).
Journal of Spacecraft and Rockets, vol. 3, Nov. 1966, p. 1695, 1696.

Investigation of the effects of spin on the performance of solid rocket motors. When the motors are subjected to spin, the combustion pressures and burning rates are usually higher than those obtained in a static environment. For an end-burning grain, these excess pressures are attributed to the effective blockage of the nozzle throat. The spin effects should be less pronounced with higher-energy propellants and with lower design combustion pressures. W.A.E.

A67-12275 #
ELECTROHYDRODYNAMIC PROPELLANT MANAGEMENT SYSTEMS FOR CRYOGENIC UPPER STAGES.
John M. Reynolds and Mathew Hurwitz (Dynatech Corp., Cambridge, Mass.).
American Institute of Aeronautics and Astronautics, Annual Meeting, 3rd, Boston, Mass., Nov. 29-Dec. 2, 1966, Paper 66-922. 10 p. 23 refs.
Members, $0.75; nonmembers, $1.50.

Consideration of the design of dielectrophoretic propellant orientation systems. The electrode requirements for a total orientation system are specified by the propellant properties, tank size, and the maximum adverse acceleration against which orientation must be achieved. A survey of the literature is presented, and selected elements of prior works are synthesized into a simple design approach. Analyses backed by experiments are used to derive criteria for orientation and collection time in a sphere. These criteria are applied to the selection and design of an orientation system for venting and liquid expulsion in the fuel tank of a lunar-mission vehicle containing 1200 lb of LH_2. The importance of avoiding electrohydrodynamic instabilities is discussed, and the implications on power supply design are discussed. Details are given of a converging plate system designed to operate at 100 kvolt. F.R.L.

A67-12281 #

THE APPLICATION OF PACKAGED HIGH ENERGY PROPELLANT REACTION CONTROL SYSTEMS.

J. Oberstone (Marquardt Corp., Van Nuys, Calif.).

American Institute of Aeronautics and Astronautics, Annual Meeting, 3rd, Boston, Mass., Nov. 29-Dec. 2, 1966, Paper 66-947. 14 p. Members, $0.75; nonmembers, $1.50.

An evaluation of several propellant combinations is conducted, based on minimum reaction control system weight, in order to establish the areas in which high energy cryogenic or space storable propellant systems prove to be more applicable than an earth storable system. Total impulses of between 10^4 and 10^6 lb-sec and storage times of up to one year are investigated for a 300-n mi earth orbit. The results indicate that for the lower total impulse region the engine and fixed hardware weights neutralize the propellant performance advantage of the cryogenic and space storable systems over the earth storable system. However, as the total impulse requirement increases, the effects of propellant performance and mission storage time become the predominant factors in determining the most attractive propellant system based on minimum system weight. For short duration missions requiring a moderate-to-appreciably-large total impulse requirement, the F_2/H_2 reaction control system offers up to a 25% weight savings over the N_2/O_4/MMH system. For longer mission durations approaching one year, the most readily applicable combinations are OF_2/B_2H_6 and F_2/BA1014. The fully cryogenic systems of F_2/H_2 and especially, O_2/H_2 are severely compromised by the large insulation weights necessary to inhibit boiloff. (Author)

A67-12284 #

A FUNDAMENTAL MODEL OF HYPERGOLIC IGNITION IN SPACE-AMBIENT ENGINES.

T. F. Seamans, M. Vanpee (Thiokol Chemical Corp., Reaction Motors Div., Denville, N J.), and V. D. Agosta (Brooklyn, Polytechnic Institute, Farmingdale, N. Y.).

American Institute of Aeronautics and Astronautics, Annual Meeting, 3rd, Boston, Mass., Nov. 29-Dec. 2, 1966, Paper 66-950. 15 p. 6 refs.

Members, $0.75; nonmembers, $1.50.

Contract No. AF 04(611)-9946.

A mathematical model of hypergolic ignition in liquid bipropellant rocket engines is presented. In addition to predicting quantitative ignition delay times for space-ambient engines, the model gives the conditions in a thrust chamber at ignition, from which ignition pressure spikes result. The model consists of analyses of (1) pre-ignition chamber pressurization based on physical kinetics of propellant evaporation and (2) reaction times based on overall chemical kinetics of ignition reactions. Propellant combinations considered are N_2O_4/MMH and N_2O_4/UDMH whose kinetic factors were experimentally determined using the theory of thermal explosions. It was found that each combination forms a sub-ignition reaction intermediate which has the characteristics of an energetic monopropellant. The effects of assumed spray drop sizes for the injected propellant streams, propellant accommodation coefficient, and nonadiabaticity of the propellant vapor/droplet system on pre-ignition chamber pressurization are obtained from the fundamental model. The present model predicts ignition delay times that are in good agreement with test values. (Author)

A67-14472

CHARACTERIZATION OF PROPELLANT BINDER INGREDIENTS THROUGH GEL PERMEATION CHROMATOGRAPHY.

Clarence Gustavson and E. A. Woychesin (Aerojet-General Corp., Sacramento, Calif.).

I & EC - Industrial and Engineering Chemistry, Product Research and Development, vol. 5, Dec. 1966, p. 314-319. 12 refs.

Contract No. AF 04(611)-8538.

Outline of the technique of gel permeation chromatography as a tool for analytical fractionation of propellant binder prepolymers and for separating and purifying labile binder ingredients. Preparation of the gels, chromatographic procedure, and molecular weight determination are explained, and the separation of glycerides, fractionation of polymers, and the separation into monomeric and polymeric components of butylene imine amide of trimesic acid (an aziridine curative for polybutadiene propellants) is described. B.B.

A67-14555 #

PROPELLANT SUPPLY AT EXTRATERRESTRIAL BASES ON THE MOON AND PLANETS [TREIBSTOFFVERSORGUNG AUF AUSSERIRDISCHEN MOND- UND PLANETENSTÜTZPUNKTEN].

E. W. Schmidt (Deutsche Versuchsanstalt für Luft- und Raumfahrt, Institut für Raketentreibstoffe, Stuttgart, West Germany).

Wissenschaftliche Gesellschaft für Luft- und Raumfahrt and Deutsche Gesellschaft für Raketentechnik und Raumfahrt, Jahrestagung 1966, Bad Godesberg, West Germany, Oct. 4-8, 1966, Paper. 12 p. 6 refs. In German.

Consideration of the structure and composition of the moon and planets' crust as determined by Luna-9, Surveyor-1, and Mariner-4 photographs, as a conceivable economical-source of fuel for interplanetary manned traffic. Lack of information on water content in lunar rock is the principal obstacle in the evaluation of lunar fuel resources. It is believed, however, that for a certain large number of launchings propellant preparation from extraterrestrial materials, rather than transportation from the earth, will be preferable. Rocket fuel production under extraterrestrial conditions is discussed. V.Z.

A67-14988 •

STATIC AND DYNAMIC BEHAVIOR OF THE LIQUID-VAPOR INTERFACE DURING WEIGHTLESSNESS.

E. W. Otto (NASA, Lewis Research Center, Cleveland, Ohio).

IN: THE FLUID DYNAMIC ASPECTS OF SPACE FLIGHT; PROCEEDINGS OF THE NATO-AGARD SPECIALISTS' MEETING, MARSEILLE, FRANCE, APRIL 20-24, 1964. VOLUME 1. [A67-14987 04-12]

Meeting sponsored by the Fluid Dynamics Panel of AGARD.

New York, Gordon and Breach, Science Publishers, Inc. (AGARDograph 87. Volume 1), 1966, p. 3-38. 29 refs.

The problems encountered in attempting to operate systems containing a free liquid-vapor interface in a weightless environment are summarized. The literature reporting the research applicable to or directed toward solutions for these problems is reviewed. Results of the research defining the configuration of the interface as a function of liquid properties and system geometry are discussed. The results of experimental studies of the dynamic behavior of the interface in response to changes in gravity level, to outflow disturbances, and to acceleration disturbances are presented. This study places particular emphasis on determination of the scaling laws that permit prediction of the interface behavior as a function of model size. (Author)

A67-15243 #

SIMULATION OF FLUID FLOW PHENOMENA IN PROPELLANT TANKS AT HIGH AND LOW ACCELERATIONS.

Michel A. Saad (Santa Clara, University, Santa Clara, Calif.) and Stephen C. DeBrock (Lockheed Aircraft Corp., Lockheed Missiles and Space Co., Space Systems Div., Propulsion Systems Dept., Sunnyvale, Calif.).

Journal of Spacecraft and Rockets, vol. 3, Dec. 1966, p. 1782-1788.

To simulate fluid behavior in propellant tanks, appropriate similarity parameters are established from dimensional analysis or from the governing equations of motion and associated boundary conditions. Experiments that determine the significance of these parameters are described using models that are geometrically and dynamically similar to the prototype. Various useful model-to-prototype ratios based on a number of dimensionless parameters are presented, and the use of similarity laws to investigate high-g propellant depletion and low-g transient fluid withdrawal in propellant tanks by 1-g testing of scale models are described. Based on such tests, a propellant tank and containment sump combination was designed and developed for the Agena vehicle and successfully used on numerous Air Force and NASA restart missions. (Author)

A67-15246 #
APPLICATION OF THE T-BURNER TO BALLISTIC EVALUATION OF NEW PROPELLANTS.
R. L. Coates (Lockheed Aircraft Corp., Lockheed Propulsion Co., Engineering Research Dept., Redlands, Calif.).
(American Institute of Aeronautics and Astronautics, Propulsion Joint Specialist Conference, 2nd, Colorado Springs, Colo., June 13-17, 1966, Paper 66-599.)
Journal of Spacecraft and Rockets, vol. 3, Dec. 1966, p. 1793-1796.
Contract No. DA-04-495-AMC-239(R).

A67-15814
THE COMBUSTION MECHANISM FOR AIR AUGMENTED ROCKET PROPELLANTS CONTAINING ELEMENTAL BORON.
J. M. Murphy (Thiokol Chemical Corp., Huntsville, Ala.).
IN: INTERNATIONAL HEAT TRANSFER CONFERENCE, 3RD, CHICAGO, ILL., AUGUST 7-12, 1966, PROCEEDINGS. VOLUME 1 (PAPERS 1-40). [A67-15800 04-33]
Conference supported by the American Institute of Chemical Engineers.
New York, American Institute of Chemical Engineers, 1966, p. 321-330.
Contract No. AF 08(635)-3680.

Analytical and experimental study of the combustion of boron in a solid propellant. A combustion mechanism is proposed for a boron-containing air-augmented propellant based on conductive, convective, and radiant heat transfer between the propellant constituents and their combustion products. Qualitative experimental data support the proposed mechanism. It is indicated that boron will burn only if its particle size is extremely small or the combustion temperature is high. B. B.

A67-15826 *
ANALYTICAL AND EXPERIMENTAL STUDY OF THE TRANSIENT LAMINAR NATURAL CONVECTION FLOWS IN PARTIALLY FILLED LIQUID CONTAINERS.
Hussein Zaky Barakat (Michigan, University, Dept. of Mechanical Engineering, Ann Arbor, Mich.) and John A. Clark (Michigan, University, Dept. of Mechanical Engineering, Heat Transfer Laboratory, Ann Arbor, Mich.).
IN: INTERNATIONAL HEAT TRANSFER CONFERENCE, 3RD, CHICAGO, ILL., AUGUST 7-12, 1966, PROCEEDINGS. VOLUME 2 (PAPERS 41-80). [A67-15815 04-33]
Conference supported by the American Institute of Chemical Engineers.
New York, American Institute of Chemical Engineers, 1966, p. 152-162. 12 refs.
Contract No. NAS 8-825.

An analytical and experimental study is reported of the two-dimensional transient laminar natural convection in a partially filled liquid container. The container walls are subjected to arbitrary time- and space-dependent temperature variation. The two-dimensional cylindrical momentum and continuity equations are transformed to the vorticity equation and an equation relating the stream function and vorticity. These equations together with the energy equation were solved numerically. An explicit finite-difference technique is developed for this purpose. A method of stability analysis suitable for partial differential equations with variable coefficients is also presented. The calculated temperature transients and the calculated Nusselt number are in good agreement with the experimental results. (Author)

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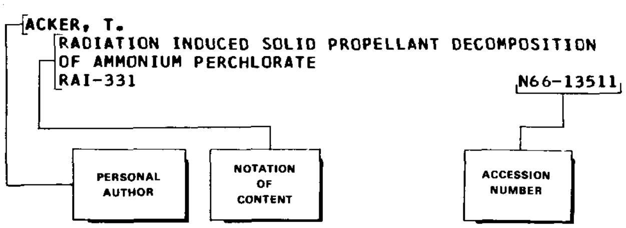

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