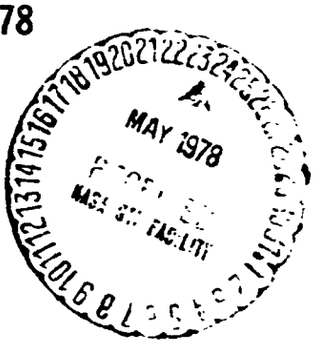
NASA TECHNICAL MEMORANDUM

NASA TM 78167

SPACE PROCESSING APPLICATIONS BIBLIOGRAPHY

April 1978



NASA

George C. Marshall Space Flight Center
Marshall Space Flight Center, Alabama

TECHNICAL REPORT STANDARD TITLE PAGE

1. REPORT NO.	2. GOVERNMENT ACCESSION NO.	3. RECIPIENT'S CATALOG NO.
NASA TM-78167		

4. TITLE AND SUBTITLE	5. REPORT DATE
Space Processing Applications Bibliography	April 1978
	6. PERFORMING ORGANIZATION CODE
7. AUTHOR(S)	8. PERFORMING ORGANIZATION REPORT #
9. PERFORMING ORGANIZATION NAME AND ADDRESS George C. Marshall Space Flight Center Marshall Space Flight Center, Alabama 35812	10. WORK UNIT NO.
	11. CONTRACT OR GRANT NO.
	13. TYPE OF REPORT & PERIOD COVERED Technical Memorandum
12. SPONSORING AGENCY NAME AND ADDRESS National Aeronautics and Space Administration Washington, D. C. 20546	14. SPONSORING AGENCY CODE

15. SUPPLEMENTARY NOTES

16. ABSTRACT

This document is a bibliography of articles, papers, and reports which discuss various aspects of the use of the space environment for materials science research or for commerical enterprise. Since the use of the space environment for materials science is a relatively new undertaking, it is the intent of this document to provide a consolidated reference for those new to the field.

The references are arranged chronologically, and several cross references are provided, as well as instructions for procurement of references.

17. KEY WORDS	18. DISTRIBUTION STATEMENT
	Unclassified-Unlimited

19. SECURITY CLASSIF. (of this report)	20. SECURITY CLASSIF. (of this page)	21. NO. OF PAGES	22. PRICE
Unclassified	Unclassified	176	NTIS

FOREWORD

The Space Processing Applications Program utilizes the unique aspects of the space environment, such as sustained low gravity, to fulfill the needs of materials sciences and manufacturing to process materials that cannot be made on Earth. Reduced gravity in space eliminates sedimentation of heavier particles and bouyancy of lighter particles and bubbles, in addition to reducing thermal convective mixing which is a natural phenomena on Earth. Space Processing can provide precise control of fluid processes, mixing of normally immiscible materials and containerless melting to achieve highly pure materials. NASA is exploring the potentialities of Space Processing and demonstrating the improved materials processes that are made possible by the new technology.

This document is a compilation of various articles, papers, and reports, which discuss aspects of the use of the space environment for materials science research which may lead to commercial enterprise. It is the intent of this document to provide a consolidated reference for those new to the field. The document will be updated as warranted.

Each of the referenced publications usually contains its own bibliography and provides additional reference materials.

The referenced publications generally are arranged in chronological order. Several cross references are provided.

Instructions for procurement of references are provided on the final page.

Erroneous entries or omissions should be reported to MSFC, PF11, with the correct entry typed out in the format desired.

TABLE OF CONTENTS

GLOSSARY OF TERMS

The following is a list of acronyms used in this document:

AAS - American Astronautical Society
AIAA - American Institute of Astronautics and Aeronautics
AIChE - American Institute of Chemical Engineers
AFB - Air Force Base
AGU - American Geophysical Union
ASME - American Society of Mechanical Engineers
BMI - Battelle Memorial Institute
ESA - European Space Agency
ESRO - European Space and Research Organization
GE - General Electric Company
GD - General Dynamics Corporation
GSFC - Goddard Space Flight Center
HDQTS - Headquarters
IAF - International Aerospace Federation
IEEG - Institute of Electrical and Electronics Engineers
IIT - Illinois Institute of Technology
IITRI - Illinois Institute of Technology Research Institute
JPL - Jet Propulsion Laboratory
JSC - Johnson Space Center
KSC - Kennedy Space Center
LMSC - Lockheed Missiles and Space Company
LRC - Lewis Research Center
MSFC - George C. Marshall Space Flight Center
MMA - Martin Marietta Aerospace
MIT - Massachusetts Institute of Technology
MDAC-ED - McDonnell Douglas Astronautics Corporation - Eastern Division
MDAC-WD - McDonnell Douglas Astronautics Corporation - Western Division
NASA - The National Aeronautics and Space Administration
NBS - National Bureau of Standards
NAR - North American Rockwell International
ORNL - Oak Ridge National Laboratory
RPI - Rensselaer Polytechnic Institute
SSL - Space Science Laboratory - Marshall Space Flight Center
SPA - Space Processing Applications Program
SPAR - Space Processing Applications Rocket Project
SAMPE - Society of Aerospace Materials and Process Engineers
SAE - Society of Automotive Engineers
SMU - Southern Methodist University
TI - Texas Instruments, Inc.
TRW - TRW System Group
UA - University of Alabama
UAC - United Aircraft Corporation
UAH - University of Alabama in Huntsville
UCLA - University of California at Los Angeles
UK - United Kingdom
USAF - United States Air Force
USC - University of Southern California
USRA - Universities Space Research Association
VA - Veterans Administration

INSTRUCTIONS

Typical entry format is as follows:

Author, Paper or Article, Author's Affiliation or Company, Source of Article, Contract, Contractor Report Number, (NSIC Library ID Number), Date, Length or Page No.

PAGE

SECTION I. GENERAL SPACE PROCESSING

A. SURVEY PAPERS

1. GENERAL

(1) McGuire, A. D., Feasibility Studies of Promising Stability and Gravity/Including Zero-G Experiments, Electro-Optical Systems, Inc., NASA CR-62482 (65X14824), April, 1964, 235 pgs.

Abstract: Zero-gravity experiments for manned orbital flight with emphasis on materials and biological aspects.

(2) Wuenscher, H. F., "Low and Zero-G Manufacturing in Orbit", NASA/MSFC, AIAA Fourth Annual Meeting and Technical Display, AIAA Paper 67-842 (67A42980), October, 1967, 9 pgs.

Abstract: Application of low and zero gravity manufacturing casting and blowing, surface tension casting,blo forming, foaming. Serpentuator system for positioning and handling.

(3) Steurer, W. H., "Processing of Materials in Space", GD/Convair Division, San Diego, California Society of Aerospace Materials and Process Engineering Proceedings, Vol. 15, Materials and Processes for the '70s, 15th National Symposium and Exhibition, (69A35588), 1969, 21 pgs.

Abstract: Detailed discussion of fundamental effects of gravity, zero gravity and induced forces on fluids, assessment of orbital processing effectiveness, cost-effectiveness and operational considerations.

(4) McCreight, L. R., "Materials Processing in Space", GE, Valley Forge, Pa., Society of Aerospace Materials and Process Engineering Proceedings, Vol. 15, Materials and Processes for the '70s, 15th National Symposium and Exhibition, (69A35598), 1969, 10 pgs.

Abstract: Preparation of high value electronic single crystals, the melting of materials and other processes benefiting from zero gravity are discussed.

Section I.A.1.

(5) Sorrells, A. R., "The Great Promise of Zero-G", Skyline, Vol. 27, No.3, (69A35490), 1969, 9 pgs.

Abstract: Containerless manufacturing of new glasses, etc., synchronous orbit manufacturing stations, computerized electric field shaping of liquid metals, bouyancy-free mixing of differing density liquid components, and crystalline materials and fibers without lattice defects.

(6) Shepard, W. G. and Vernon, A.R., "Materials Science and Processing in Space", Appendix H, NASA Proceedings of the Winter Study on Uses of Manned Space 1975- 1985, (70N17034), 1969, 11 pgs.

Abstract: Properties of space environment relevant to materials science and processing: gravitational field, space vacuum, radiation.

(7) Skeer, H., Sortland, L. D., Vernon, A.R., "Uses of Manned Spaceflight for Materials Science and Processing in Space", Bellcomm, Inc., Washington, D. C., (69X75273), March 21, 1969, 13 pgs.

Abstract: Ceramics, metallurgy, crystal growth, refining; gravitational fields, radiation effects.

(8) Wuenscher, H. F., "Space Manufacturing Unique to Zero Gravity Environment", NASA/MSFC, AAS and GRSA Joint National Meeting, Denver, Colorado, (69A42844), June 17-20, 1969, 30 pgs.

Abstract: Buoyancy - and thermal convection-sensitive manufacturing processes and molecular force controlled processes.

(9) Wuenscher, H. F., "New Development in Space Manufacturing", NASA/MSFC, (70N114670), October 21, 1969, 9 pgs.

Abstract: Tabulation of unique space processes (zero and low gravity) and assessment of current technology and recommendations for future development.

Section I.A.1.

(10) Von Braun, W., "Factories in Space," Popular Science, NASA/MSFC, December 1969.

(11) Wuenscher, H. F., "New Development in Space Manufacturing", NASA/MSFC, (70N20536), February 5, 1970, 9 pgs.

Abstract: Feasibility of manufacturing during weightlessness.

(12) Wuenscher, H. F., "Unique Manufacturing Processes in Space Environment", NASA/MSFC, (71N26010), April 1970, 10 pgs.

Abstract: Experiments in development for Skylab; NASA and industrial participation in space processing and manufacturing experiments.

(13) Steurer , W. H., Gorham, D. J., Processes for Space Manufacturing, GD/Convair, San Diego, Cal., Final Report NASA Contract NAS8-24 79 (Contract No. GDC-DBG70-001), June 1970.

(14) McCreight, L. R., "The Potential of Space Processing", Research/Development, GE, Valley Forge, Pa., (70A37926), August 1970, 2 pgs.

Abstract: Float zone refining and semi-conductor crystal growth; electronic crystals grown from solution; melting and casting of metals, glasses, and ceramics; slip casting of metals; centrifugation and electrophoresis of biologicals.

(15) Wuenscher, H. F., "Manufacturing in Space", New Scientists, Vol. 47, NASA/MSFC, (70A43075), September 10, 1970, 4 pgs.

Abstract: Skylab Orbital Workshop experiments: metal composites from eutetic Al-Co and monotectic Al-In alloys, metallic whisker composites from eutectic Al-Co with added sapphire whiskers; spherical castings of pure Ni, Ni 12% Sn, and alloy "Star J stellite"; single crystal growth; electron beam welding and cutting, exothermic brazing of stainless steel tubes.

(16) Tegtmeier, A., Franke, B., "Possibilities for Production in Space", Fourth DGLR Annual Meeting, Baden-Baden, W. Germany, (72N21897), October 11-13, 1971, 89 pgs.

Abstract: Survey of manufacturing, potential in orbital workshops. Methods and processes in chemistry, pharmaceuticals, optical components, crystal growth, metallurgy and composite materials. (In German)

(17) Dooling, Jr., D., "New Industrial Revolution in Space", Spaceflight, Vol. 13, (72A11961), December, 1971, 5 pgs.

Abstract: Spherical and hollow ball bearings, special metal shapes, metal foams, intermetallics; adhesion and containerless casting of metals; special composites; high quality crystals: glasses; vaccines and drugs. Apollo 14 and 15 materials processing experiments are described (electrophoresis, composite casting, heat flow and convection, and liquid transfer). Space Shuttle and Space Station roles in space manufacturing.

(18) Wuenscher, H. F. "Materials Processing in Zero Gravity--Space Manufacturing", NASA/MSFC Proceedings of the Twenty-third Congress of Astronautical Research, (74A24969), October 8-15, 1972, 13 pgs.

Abstract: Apollo 14 and Skylab experiments on electrophoretic separation, M551 metals melting, M552 exothermic brazing, M553 sphere forming, M554 composite casting, and M555 GaAs crystal growth.

(19) Wuenscher, H. F. "Exploiting Gravity Fields Less Than IG: Manufacturing in Space", NASA/MSFC, Astronautics, Vol. 10, No. 9, September, 1972, pgs. 42-54.

Abstract: Application of gravity control and vacuum, temperature, pressure and radiation characteristics of space to liquid-matrix preparation of composites, fine grain castings, supersaturated alloys, immiscible liquid-phase combinations, containerless free suspension, surface tension casting and drawing, adhesion casting and controlled density casting.

Section I.A.1.

(20) Yost, V. H., "Experimental Studies of Manufacturing Processes Performed in Zero-G", NASA/MSFC, Research Achievements Review, Vol. 4, No. 7, (73N22922), February, 1973, 40 pgs.

Abstract: Reduced gravity manufacturing experiments in support of Skylab, etc. Methods to obtain short periods of near zero gravity.

(21) Belew, L. F., Stuhlinger, E., Skylab - A Guidebook, NASA/MSFC, GAP Stock 3300-00508, 1973, pgs. 187-196.

Abstract: Describes Skylab hardware, mission objectives and experiments.

(22) "Materials Science and Manufacturing in Space", Skylab News Reference, NASA Office of Public Affairs, Washington, D.C., March, 1973, pgs.III-47-52.

Abstract: Brief summaries of experiment objectives and hardware to be flown on Skylab.

(23) Stuhlinger, E., "Materials Processing Under Zero Gravity - An Assessment After Skylab", NASA/MSFC, Proceedings of the Third Space Processing Symposium, Vol. I, M-74-5, June, 1974, pgs. 507-525.

Abstract: New potential product areas based on Skylab results.

(24) Lucas, W. R., "The Processing of Materials in Weightlessness", NASA/MSFC, First Waite Philip Fishel Lecture, April 17, 1974.

(25) Siebel, M.P.L., "Introduction to Space Processing", Proceedings of the Third Space Processing Symposium, Vol.I, M-74-5, June, 1974, Pgs. 3-23.

Abstract: Brief history of space processing activities through Skylab - drop tower, KC-135, Apollo, Skylab, rockets.

Section I.A.1.

(26) Bredt, J. H., "Projected Future Space Processing Activities", NASA/HDQTS, Proceedings of the Third Space Processing Symposium, Vol. II, M-74-5, June, 1974, pgs.1045-1051.

Abstract: Space Processing Applications program goals for ASTP, sounding rockets, Shuttle payloads.

(27) Stine, H., "Third Industrial Revolution: The Exploitation of the Space Environment", Spaceflight, Vol. 16, No. 9, Sept., 1974, pgs. 327-334.

(28) Steg, L., McCreight, L. R., "Space Processing - Status, Prospects and Problems - 1974", GE, Valley Forge, Pa., 23rd IAF Congress, Amsterdam, September 30-October 5, 1974.

(29) Stuhlinger, E. H., "Materials Processing in Space: A Lock Toward the Future", NASA/MSFC, Astronautics and Aeronautics, May, 1975, pgs. 20-21.

(30) Bredt, J. H., Montgomery, B.O., "A Challenge to Industry", NASA, Astronautics and Aeronautics, May, 1975, pgs. 21-41.

Abstract: Describes the status and results to date of the material science research in space and discuss future programs and new challenges for industry.

(31) Bredt, J. H., "The NASA Space Processing Program", NASA/HDQTS, Second European Symposium on Material Sciences in Space, Freacati, Italy, April 6-8, 1976.

Abstract: Discussions of commercial use of space for research and manufacture. NASA rocket program (SPAR) and Shuttle flights.

2. MEETINGS/ANNUAL REPORTS

(1) Mettler, R. F., "Space Manufacturing", AAS 13th Annual Meeting; Commercial Utilization of Space, AAS Paper - 167-128, May, 1967.

Section I.A.2.

(2) Beyerle, F. J., Cooper, C. R., Hoppes, R. V., Nichols, R., Van Allen, R. T., "Manufacturing Engineering Research at MSFC, NASA Research Achievements Review, Vol. 2, (69N18070), 1968.

Abstract: Electron beam welding in space.

(3) "Space Processing and Manufacturing", NASA/MSFC Report No. MS-69-1, October 21, 1968.

(4) "Manufacturing Technology Unique to Zero Gravity Environment", NASA/MSFC Conference, NASA-TM-X-62504, (69X77390), November 1, 1968, 234 pgs.

Abstract: Various views of requirements for unique materials, e.g., glass, metal crystals; and benefits of gravitational fields, materials handling in space.

(5) Wahe, B. W., "Analysis of Selected Opportunities for Manufacturing in Space", Space Technology and Society, 6th Space Congress of Canaveral Council of Technical Societies, Cocoa Beach, Florida, (69A35066), Issue 18), March 17-19, 1969.

(6) "Space Processing and Manufacturing Meeting", NASA/MSFC Conference, NASA-TM-X-62560, (70N14651), October 21, 1969, 546 pgs.

Abstract: Research and development work on materials manufacturing and production engineering in space, emphasizing effects of reduced gravity on crystal growth and metal working, exobiology, glasses, etc. Includes N 70-14652--N 70-14679.

(7) "Space Processing Meeting", NASA/MSFC, NASA-TM-X-53993 (70N20517), February 5, 1970, 554 pgs.

Abstract: Production engineering aspects of materials processing and industrial manufacturing with applications to orbiting laboratories and workshops, especially the effects of reduced gravity. Includes N70-20518--N70-20548.

Section I.A.2.

(8) "Unique Manufacturing Processes in Space Environment", 7th Space Congress, Cocoa Beach, Florida, NASA-TM-X-67178 (71N26009), April 23, 1970, 72 pgs.

Abstract: Zero-G melting and solidification, space manufacturing processes, facilities and experiments, chemical and biochemical space manufacturing; positioning and handling in weightlessness.

(9) "Space Processing and Manufacturing", NASA/MSFC, Conference, November 1, 1970.

(10) "Materials Science and Manufacturing", Reference Earth Orbital Research and Application Investigations, GD/Convair and TRW Contracts with NASA, NHB-7150.1 - Vol. 6 (72N2280), January 15, 1971, 102 pgs.

Abstract: Development of materials science and manufacturing facilities for installation aboard space stations.

(11) McCreight, L. R., Steg, L., "Space Processing - Projections to 2000 A. D.", 23rd IAF Congress, Vienna, Austria, (72A45157), October, 1972, 15 pgs.

Abstract: Economic zero-gravity processing of materials in liquid or molten state, single crystal electronic materials, and high-purity biologicals on space shuttle in the 1980's.

(12) Paton, B. E., "The Problems of Space Technology and Their Influence on Science and Technics, 24th IAF Congress, Baku, Azerbaidzhan, USSR, (74A12843), October, 1973, 17 pgs.

Abstract: Soviet test equipment, manual and automatic tools, program controlled plants and key factors (weightlessness, deep vacuum, and temperature) in their use.

Section I.A.2.

(13) Passaglia, E., Parker, R. L. (editors), "NBS Materials Science and Manufacturing in Space Research", National Bureau of Standards Final Report, NBISR73-402, November, 1973.

Abstract: Summary of NBS work in support of NASA Space Processing programs (Nov. 1972 - Nov. 1973). Five Individual tasks covered.

(14) Passaglia, E., Parker, R. L. (editors),"NBS Materials Science and Manufacturing in Space Research", National Bureau of Standards Annual Report (November '73 - November '74) NBSIR 74-611, November 1974.

Abstract: Summary of NBS tasks performed in support of NASA Space Processing programs. (Nov. 1973-Nov. 1974).

(15) Bredt, J. H., "Annual Review of Materials Science in Space", COSPAR Paper R.1.1. NASA Headquarters, 1975.

(16) "Materials", NASA Office of Aeronautics and Space Technology (OAST) and Old Dominion University, Vol. VII of XI, Final Report of Summer Workshop, August 3-16, 1975.

(17) Passaglia, E., Parker, R. L. (editors),"NBS Materials Science and Manufacturing in Space Research", National Bureau of Standards Annual Report (November '74 - December '75), NBSIR 76-980, January, 1976.

3. MISSION SUMMARY REPORTS

(1) The Combined Laboratory and KC-135 Aircraft Zero-G Test Program Progress Report, GD, San Diego, Cal., Contractor Report No. GDA-AE61-0593 (69X72370), June 22, 1961, 59 pgs.

Abstract: Heat transfer, liquified gases, film boiling, weightlessness, etc.

(2) Lundquist, C. A., "ASTP Multipurpose Furnace Experiments", NASA/MSFC/SGL, ESRO Space Processing Symposium, Frascati, Italy, March, 1974.

Section I.A.3.

(3) Proceedings of the Third Space Processing Symposium: Skylab Results, Vols. 1 and 2, NASA/MSFC, M-74-S, June, 1974, 1078 pgs.

Abstract: Welcoming address, Introduction, Closing Remarks, and thirty-eight papers covering results of Materials Processing Experiments conducted on Skylab and several related activities. Individual papers contain preliminary Skylab experiment data.

(4) Bannister, T. C., "Skylab Science Demonstrations", Proceedings of the Third Space Processing Symposium, Vol. 1, M-74-S, June, 1974, pgs. 491-507.

Abstract: Preliminary results of nine of the twelve Skylab science demonstrations are presented: Diffusion in Liquids, Ice Melting, Liquid Floating Zone. Immiscible Liquids, Liquid Films, Rocelle Salt Growth, Deposition of Silver Crystals, Fluid Mechanics, Charged Particle Mobility.

(5) Skylab Space Processing Experiment Review, MSFC Meeting Results prepared by USRA, July, 1974.

(6) "Materials Processing Experiments", MSFC Skylab Corollary Experiment Systems Mission Evaluation Report, Section V, NASA/MSFC, TMX-64820, September, 1974.

Abstract: Skylab Materials Processing hardware evaluation - M512 and M518 facilities. Scientific evaluation of experiment samples is not covered, only hardware operation and experiment performance.

(7) Materials Processing", MSFC Integrated Experiments Preliminary Report, Section III D, NASA/MSFC, TMX-64881, November, 1974, 145 pgs.

Abstract: Preliminary results of Skylab experiments.

Section I.A.3.

(8) Guili, R. T. (e'itor), Apollo-Soyuz Test Project Preliminary Science Report, NASA/JSC, TMX-58173, February, 1976.

Abstract: Summary report of the ASTP experiments. Preliminary results included on the ten material science for electrophoresis experiments.

(9) Space Processing Applications Rocket (SPAR) First Flight Report, NASA/MSFC (In preparation), (to be published approximately October, 1976).

Abstract: Summary report of the nine materials science experiments flown on the first SPAR flight December, 1975.

4. EUROPEAN REPORTS

(1) "Views of the ESRO - Processing and Manufacturing in Space Group", ESRO Report No. ESRO/PA/R108, 1973.

(2) "Views of the ESRO - Group on Space Electrophoresis in the Spacelab Programme", ESRO Report No. ESRO/PA/R107, 1973.

(3) "European Views on Processing and Manufacturing in Space", ESRO-CERS Applications Summer Study, U. S. National Academy of Engineering, July, 1974.

(4) Beck, R., Grunthaler, K. H., Sethna, D. N., Tschulena, R., Winter, H., "Assessment of the Results of the Skylab Space Processing Experiments with Respect to Their Scientific-technical Significance", Battelle-Institute e.V.; Frankfort am Maim, W. Germany, Final Report for ESRO Contract SC/43/RQ, October, 1974.

Abstract: An independent, impartial evaluation for ESRO of the results of Apollo and Skylab experiment results to obtain a realistic basis for planning experiments to be carried-out in Spacelab.

Section I.A.4.

(5) Abstracts of Papers Presented at Second European Symposium on Materials Sciences in Space, Frascati, Italy, April 6-8, 1976, 48 abstracts.

Abstract: Papers presented by both U. S. and European materials scientist, engineers, and managers.

(6) Seibert, G., "Overview of Materials Sciences Activities in Europe-Experiments and Experiment Studies, European Space Agency (ESA), Neuilly-sur-Seine, France", Second European Symposium on Material Sciences in Space, Frascati, Italy, April 6-8, 1976.

Abstract: ESA Activities in materials science, first Spacelab payload recommended order of priority ESA study result in facility and furnace design.

(7) Greger, G., "Overview of Materials Science Programme in Germany", Bundesministerium fuer Forshung and Technolgie, Bonn, W. Germany, Second European Symposium on Materials Sciences in Space, Frascati, Italy, April 6-8, 1976.

Abstract: German space processing program discussed, study results of planning activities for Shuttle/ Spacelab, and a sounding rocket program.

B. FACILITIES

1. GENERAL

(1) Parks, P. G., Facility for Space Experiment M512 and M979, NASA/MSFC, October 1967.

(2) Steurer, W. H., Selected Examples for Space-Manufacturing Processes Facility and Experiments, GD/Convair, San Diego, Cal., November 1969.

(3) Parks, P. G., Facility for Space Experiments M512 and M479, NASA/MSFC, Huntsville, Alabama, (70N14664, Issue 4), October 21, 1969, 9 pgs.

Abstract: Integrated facility to conduct space manufacturing engineering experiments: vacuum chamber, 2 kw electron beam welding and heating systems.

(4) Steurer, W. H., "Selected Examples for Space Manufacturing Processes, Facilities, and Experiments", GD/Convair, San Diego, Cal., Proceedings of Seventh Space Congress, Cocoa Beach, Florida, (71N26012), April 1970.

Abstract: Space manufacturing processes based on the potentials and limitations of the low gravity environment.

(5) Low Cost Payload Design Concepts Study - Volumes 1 and 2, LMSC, Sunneyvale, Cal., NASA/MSFC, Contract NAS8-28960, LSMC 8-28960-D 336289, June, 1973.

(6) Hart, R. K., Develop a High Intensity Electron Gun, Georgia Institute of Technology, Atlanta, Georgia, NASA/MSFC Contract NAS8-29860, July 31, 1973.

(7) Brashears, M. R., Robertson, S. J., Research Study on Materials Processing in Space Experiment M512 , LMSC, Huntsville, Alabama, Final Report NASA/MSFC Contract NAS8-28729, December, 1973.

Section I.B.1.

(8) Kukhtenko, A. I., Merkueov, V. I., Samoilenko, I.U.I., Ladikov-Roev, I.U.I., "Distributed Automatic Control of Technological Processes Under Weightless Conditions", 24th IAF Congress, Bakw, Azerbaidzhan, USSR, October 7-13, 1973 24 pgs.

Abstract: Automatic control (three dimensional resolution, wavelength-sensitive perturbation response, amplification capacity) techniques applied to weightless liquid metal and plasma systems. (In Russian).

(9) McDermit, J. H., Solar Energy Concentrator System for Crystal Growth and Zone Refining in Space, LMSC, Huntsville, Alabama, NASA Contract NAS8-30268, Report LSMC/HREC-TR-D390664, February, 1975, 89 pgs.

Abstract: Feasibility study of using solar concentrators for crystal growth and zone-refining in space.

(10) Automated Space Processing Payloads Study, Be.dix Corporation, Aerospace Systems Division, Ann Arbor, Michigan, NASA/MSFC Contract NAS8-30741, January, 1975.

Abstract: Evaluation of how well automatic control and material handling devices can satisfy hardware and operational requirements for space processing.

(11) Parks, P. G., Skylab Materials Processing Facility Experiment Developer's Report, NASA/MSFC, TMX-64977, July, 1975.

Abstract: Detailed description of the Skylab M512 facility including systems and associated experiment hardware.

2. FURNACE SYSTEMS

(1) Sparks, V. W., Preliminary Design of a High Temperature Space Manufacturing Furnace, LMSC, Huntsville, Alabama, NASA Contract NAS8-21347, Report NASA-CR-102604 (N70-23933), January, 1970.

Section I.B.2.

(2) Seidensticker, R. G., Duncan, C. S., Johnson, R. A., Feasibility Study of a Multipurpose Electric Furnace System for Space Experiments, Westinghouse, Pittsburgh, Pennsylvania, NASA Contract NAS8-26122, Report NASA-CR-119793 (71X10881), 1971.

(3) Eliss, A., Dussan, B., Shadis, W., Frank, L., Feasibility Study of a High Temperature Radiation Furnace for Space Applications, Weiner Associates, Inc., Cockeysville, Maryland, NASA Contract NAS8-28059, Report NASA-CR-124458 (N73033905), 1972.

(4) Mazelsky, R., Duncan, C.S., Multipurpose Electric Furnace System, Westinghouse, Pittsburgh, Pennsylvania, NASA Contract NAS8-30289, Report WRL 8030289-MPR-1, July 31, 1973.

(5) Halbaeh, C. R., Page, R. J. Arthur, P.D., 2200°C Oxidizing Atmosphere Furnace for Space Manufacturing, Artcor Corporation, Irvine, Cal., NASA Contract NAS8-29769, (74Z18866), January, 1974.

(6) Seidensticker, R. G., McHugh, J.P., Evaluation of the Performance of the M518 System During the Skylab 3 Mission, Westinghouse, Pittsburgh, Pennsylvania, NASA Contract NAS8-28271, February, 1974, 40 pgs.

Abstract: Comparison of M518 performance predicted from ground-based data and the actual performance in flight.

(7) Aldrich, B. R., "Furnace Systems Development", Proceedings of the Third Space Processing Symposium, Vol.II, M-74-S, June, 1974, pgs. 581-595.

Abstract: Discussions of various types of furnace designs from Apollo through ASTP.

(8) Chi, J.W.H., Seidensticker, R.G., Duncan, C.S., "Thermal Design and Analyses of Skylab Multipurpose Furnace and Experiments", Westinghouse, Pittsburgh, Pa., 1974 AIAA/ASME Thermophysics and Heat Transfer Conference, Boston, Mass., July, 1974.

Section I.B.2.

(9) Eyer, A., Zimmerman, H., Nitsche, R., "A Radiation Furnace for Zone-Crystallization Experiments in Space", Kristallographisches Institut der Universitat, Freiburg, Germany, Second European Symposium on Material Sciences in Space, Friascati, Italy, April 6-8, 1976.

Abstract: A highly efficient radiation furnace for space processing of materials has been constructed. Temperatures exceeding 2300°K can be achieved.

C. GENERAL APPLICATIONS

1. ECONOMIC STUDIES

(1) Ulrich, D. R., McCreight, L. R., Economic Analysis of Crystal Growth In Space, GE, Space Sciences Laboratory, Valley Forge, Pa., NASA Contract NAS8-27942, GE 8-27942-MPR-1, September, 1971.

(2) Ulrich, D. R., Chung, A.M., Yan, C. S., McCreight, L. R., Economic Analysis of Crystal Growth in Space, GE, Valley Forge, Pa., NASA Contract NAS8-27942, Report NASA-CR-12395, Contract Report No. DCN-1-1-50-13668(1F), (N73-12806), July, 1972.

(3) Woodcock, G. R., "On Economics of Space Utilization", Boeing, 23rd IAF Congress, Vienna, Austria, (72A45216), October, 1972, 26 pgs.

Abstract: Economic analysis for assessing commercial space applications. Some treatment of manufacturing in space.

(4) Scarff, D. D., Bloom, H. L., A Business Man Views Commercial Ventures in Space, GE, Valley Forge, Pa., AIAA paper 73-78, NASA Contract NAS8-28179, (73A17640), January, 1973.

Abstract: Technical, resource planning and marketing steps necessary for space research and development by industrial groups.

(5) Vachon, R. I., et al., "Economic Analysis of Materials Processing in Space", Auburn University Study, Final Report NASA/MSFC Contract NAS8-29881, June, 1975, 251 pgs.

Abstract: Economic analysis using econometric and cost benefit analysis techniques was performed to determine feasibility of space processing high priority tungsten targets for medical x-ray tubes, turbine blades for jet engines, and electrophoresis for biological applications.

Section I. C. 1.

(6) Bloom, H. L. (study manager), Study for Identification of Beneficial Uses of Space - Phase I., II., III., GE, Valley Forge, Pa., NASA Contract NAS8-28179, Phase I - Dec., 1972, Phase II - Nov., 1973, Phase III - Nov., 1975.

Abstract: Phase I involved identification of over 100 ideas for potential products, processes and services that might possibly be developed or produced in space facilities. Phase II investigated the technology and programmatics involved in development of 4 products chosen from Phase I list. Phase III was concerned with the business analysis and planning for the commercial development and production of the four Phase II products.

(7) Feasibility Study of Commercial Space Manufacturing, McDonnell Douglas Astronautics Company-Eastern Division, St. Louis, Missouri, Final Report NASA Contract NAS8-31533, Contractor Report No. MDC E1400, December 20, 1975.

(8) "NASA Seeks Industry Space Processors", Aviation Week & Space Technology, January 26, 1976, pgs. 46-64.

2. EQUIPMENT/SYSTEMS

(1) Faber, W., Greeb, F., Boyd, R., Study of Tooling Concepts for Manufacturing Operations in Space, MMA, Denver, Colorado, Final Report NASA contract NAS8-21279, NASA-CR-109989 (N70-34762), April 26, 1969.

Abstract: Serpentuator, powered mechanical linkage device, can serve as means of transport, guidance, stabilization and rendezvous for space manufacturing operations.

(2) Kostoff, R. N., "A Satellite Wake Region as an Ultrahigh Vacuum Chamber", Bellcomm Inc., Washington, D. C., Memorandum B69-65029, May 6, 1969.

Section I.C.2.

(3) Kostoff, R.N., "Use of a Satellite Wake Region as a Vacuum Pump", Bellcomm, Inc., Washington, D. C., Memorandum B70-04015, April 7, 1970.

(4) Boese, A., Design, Construct, Test and Evaluate a Zero Gravity Experiment, (72K10212), April 30, 1973.

(5) Bird, J. O., Waltz, D. M., Requirements and Concepts for Materials Science and Manufacturing in Space Equipment Study, Vols. 2D and 3, TRW Systems Group, Redondo Beach, Cal. NASA Contract NAS8-28938, NASA-CR-120119 (74X10034), July 1973.

(6) Paton, B.E., et al., "Test Stands for Studying Technological Processes Under Simulated Space Conditions", 24th International Astronautical Congress, Baku, Azerbaidzhan, USSR, (74A12844, Issue 2), October 7-13, 1973, 12 pgs.

Abstract: In Russian - Review of Soviet equipment designed for technological experiments on manned space missions and description of ground based test facilities.

(7) Seidensticker, R.G., "System Design for Free Fall Materials Processing", Westinghouse, Pittsburgh, Pa., Proceedings of the Third Space Processing Symposium, Vol. II, NASA/MSFC M-74-%, June, 1974, pgs. 595-603.

Abstract: Various design considerations (such as size, weight, power, heat, etc.) are imposed on equipment used in spacecraft. The Skylab M518 furnace system and the ASTP MA-010 system are used as examples.

3. PROCESSES

(1) Kloepper, D., Witt, R., "Boron Filament Manufacture in Space - A Literature Feasibility Study", Grumman Aerospace Corp., Bethpage, N.Y., NASA/MSFC Contract, (70N14655, Issue 4), October 21, 196_, 36 pgs.

Section I.C.3.

Abstract: Review of earth manufacture of boron filament technical literature. Techniques for space manufacture: substrate deposition, glow discharge, and RF positioning with induction or hot gas heating. Boron compounds, filaments.

(2) Libby, W. R., Payton P., Industrial Chemistry in Space, UCLA, NASA/MSFC Contract, Contractor Report No. NGL-05-007-003 (70N20547), February 5, 1970.

Abstract: Space environment air-free chemical preparation, improved purity. Crystal growth, ultrapure metals, chemical reactions.

(3) Griffin, R. N., Henry, E. C., McCreight, L. R., Rubin, B.A., Investigation of the Preparation of Materials in Space, GE, Valley Forge, Pa., NASA Contract NAS8-24662, NASA-CR-102749 (70N31862), March, 1970.

(4) Kober, C. L., "Chemical and Biochemical Space Manufacturing", Martin Marietta, Denver, Colorado, Technology Today and Tomorrow, 7th Space Congress of Canaveral Council of Technical Societies, Cocoa Beach, Florida, (70A33719) April, 1970, 9 pgs.

Abstract: Prospects for space manufacturing of glasses, crystals, filaments, solid lubricants, cermets, cast composites, perfect spheres, sinters, seed materials, vacines, enzymes, isotopes, antibiotics, and polymers. Liquid phase physical chemistry of zero-g instrumentation, and scaling laws are reviewed.

(5) Problems and Uses of Outer Space, Carnegie-Mellon University, Pittsburgh, Pa., NASA Contract NAS8-25202, Contractor Report No. CMU-8-25202-FR-May 1970, May 8, 1970.

(6) Steurer, W. H., Gorham, D. J., Processes for Space Manufacturing - Definition of Criteria for Process Feasibility and Effectiveness, GS/Convair Division, NASA Contract NAS8-24979, NASA-CR-61334 (70N39375), June, 1970.

Section I.C.3.

Abstract: Potentials, limitations, and priorities of twenty-four processes for space manufacturing. Defines scientific and engineering criteria used in determining feasibility.

(7) Bauer, H. F., "New Developments of Fabrication in Orbit", Georgia Institute of Technology, 11th European Space Symposium, Berlin, Germany, (71A32856), May, 1971.

Abstract: Degassing and bubble migration in liquified materials without gravity. Metal and optical lens casting, crystal growth.

(8) Gatos, H. C., "Space Environment - A New Dimension in the Preparation of Unique Solids", MIT, Cambridge, Mass., (73N13861), 1972, 3 pgs.

Abstract: Effect of nongravitational environments on the development of homogeneous materials that cannot be manufactured on earth.

(9) Steurer, W. H., Kaye, S., Gorham, D. J., Space Processes for Extended Low-G Testing, GD/Convair Division, San Diego, Cal., NASA Contract NAS8-28615, NASA-CR-124285 (N73-31752), June 15, 1973.

Abstract: Ground based low-g experiments verification of space process capabilities. Defines a minimum equipment inventory of modular design. Procedures for synthesis and definition of dedicated and mixed rocket payloads.

(10) Review, Study, and Evaluation of Possible Flight Experiments Relating to Materials Processing in Space, Universities Space Research Association, Charlottesville, Virginia, Final Report NASA Contract NAS8-27734, November, 1973.

Section I.C.3.

(11) "Space Processing as Related to Five Discipline Areas", for use by Academy of Engineering 1974 Summer Panel, Universities Space Research Association, Charlottesville, Virginia, Report under Grant NGR 47-102-3, April 15, 1974.

Abstract: Information prepared by the five USRA committees of discipline areas. Fluid Mechanics and Heat Transfer, Containerless Processing, Solidification of Metals, Preparation of Glasses, Electrophoretic Separation.

(12) Bannister, T. C., "Earth Activities, Appendix I, Materials Processing in Space", Outlook for Space 1980-2000, Working Paper Input to Outlook for Space Reference Volume, December 20, 1974.

(13) Hibbs, A. R., Maserjian, J.,Boundy, R. A., "Part Five: Management of Matter", Outlook for Space Reference Volume - A Forecast of Space Technology (1980-2000), NASA Task Group, July 15, 1975.

(14) Erben, E., "Quality Increase of Space Processed Turbine Blades", MAN - Munchen, New Technologie, Munchen, Germany, Second European Symposium on Material Sciences in Space, Frascati, Italy, April 6-8, 1975.

PAGE

SECTION II. SPACE MANUFACTURING MANAGEMENT AND PLANNING

A. GENERAL PLANNING

(1) Hoppes, R., Habermann, J., Program for Material Processing in Space, NASA/MSFC, December, 1968.

(2) Williams, J. R., "Space Manufacturing Modules", 6th Space Congress of Canaveral Council of Technical Societies, (69A35067), March, 1969, 18 pgs.

Abstract: Proposed program to develop space manufacturing in three phases: investigation of zero gravity effects on processes in earth orbit by package in Apollo Applications Program Orbital Workshop; improved space manufacturing chamber; and room size manufacturing module.

(3) Armstrong, W. O., "Earth Orbital Payload Planning", NASA Space Processing and Manufacturing Meeting, Washington, D. C., (70N14652), October, 1969.

Abstract: Plans for space processing and manufacturing experiments on AAP Workshops, space station and shuttle.

(4) Bannister, T. C., Arnett, G., A Proposed Crystal Growth Program for Space Processing Including Flight Experiments, NASA/MSFC, Jan., 1970.

(5) Armstrong, W. O., "Earth Orbital Payload Planning", NASA/HDQTS, NASA Space Processing and Manufacturing Meeting, Washington, D. C., (70N20518), February, 1970, 30 pgs.

Abstract: Plans for space processing and manufacturing experiments in next decade. Procedures for soliciting and selecting industrial inputs. Policies on funding and proprietary rights.

(6) Kober, C. L., "Commercial Use of Space Station", MMA, Denver, Colorado, 16th Annual AAS Meeting, Anaheim, Cal., AAS Paper 70-036 (70A34791), June, 1970.

Section II.A.

(7) Bredt, J. H., Materials Science and Manufacturing in Space Program, NASA HQ MT-70-6788, Rev. 8-27-702, August 1970.

(8) Carey, T., Quantock, C., et al., "Marshall Space Flight Center - Materials Science and Manufacturing in Space Program Plan", September, 1970.

(9) Armstrong, W. O. Bredt, J. H., "Status and Plans of NASA's Materials Science and Manufacturing in Space/MS-MS/Program", NASA/HDQTS, Proceedings of the First International Space Congress, Huntsville, Alabama, (72A18621), November, 1971.

(10) Armstrong, W. O., Bredt, J. H., "Status and Plans of NASA's Materials Science and Manufacturing in Space (MS/MS) Program",NASA/HDQTS, Space for Mankind's Benefit, (73N13860), 1972, 8 pgs.

Abstract: Space Shuttle preparations for possible manufacturing operations on permanently orbiting space stations.

(11) Levy, M., "Review of European Space Projects After 1980", The Second Fifteen Years in Space, Proceedings of the Eleventh Goddard Memorial Symposium, Washington, D. C., (74A14472), March, 1973, 8 pgs.

Abstract: Future development is based on current efforts in aeronautics, meteorology, telecommunications. Use of Spacelab as part of the Space Shuttle.

(12) Berge, K. D., Tegtmeier, A., "Spacelab - Europe's Participation in Manned Space Flight and its Long-Term Aspects", ERNO, Raumfabrttechnik Gmbh, Bremen, Germany, DGLR Paper 73-075 (74A17182), September 24-28, 1973, 26 pgs.

Abstract: (In German) Remote sensors, earth resources, air pollution; space manufacturing, mission planning, space shuttle, spacelab economic factors.

Section II.A.

(13) Petrov, B. N., Orbital Stations and the Study of Earth from Space, Joint Publications Research Service, Arlington, Virginia, Contractor Report No. JPRS-59650 (73N27754, Issue 18), July, 1973.

(14) "The Space Processing Program", Chapter VI, The Space Applications Program 1974, NASA/HDQTS Office of Applications, 1974.

(15) Yaffee, M. L., "Processing Experimenters Look to ASTP", Aviation Week and Space Technology, July 8, 1974, pgs.28-30.

B. SKYLAB PROGRAM PLANNING

(1) Lundholm, J. G., Werner, L. M., White, J. H., "Skylab as Factory, Worksite and Observatory", Astronautics and Aeronautics, Vol.9, (71A31460), June, 1971, 11 pgs.

Abstract: Discussion of experiments (in science, technology, materials science and manufacturing in space) and support facilities on Skylab.

(2) Bredt, J. H., "New Space Processing Experiments for the Skylab Missions", 23rd IAF Congress, Vienna, Austria, (72A45125), October, 1972, 25 pgs.

Abstract: Application of gravity control and vacuum, temperature, pressure and radiation characteristics of space to liquid-matrix preparation of composites, fine grain castings, supersaturated alloys, immiscible liquid-phase combinations, containerless free suspension, surface tension casting and drawing, adhesion casting and controlled density casting.

(3) Tobin, J. M., Research Study on Materials Processing in Space Experiment Number M512-Phase A Preparation of Ground Base Study Plan, Westinghouse, Pittsburgh, Pa. NASA Contract NAS8-28730, Contractor Report No. WANL L-792, August 1972.

(4) Tobin, J. M., Kossowsky, R., Research Study on Materials Processing in Space Experiment Number M512-Phase B Laboratory Test Program on M552 and M553 - Summary Report, Westinghouse, Pittsburgh, Pa., NASA Contract NAS8-28730, Contractor Report No. WANL L-848, July, 1973.

(5) Winkler, C. E., Scientific Involvement in Skylab by the Space Sciences Laboratory at MSFC, NASA/MSFC, (73N20886), February, 1973.

Abstract: Includes materials science/manufacturing in space.

Section II.B.

(6) Tobin, J. M., Kossowsky, R., Research Study on Materials Processing Experiment Number M512, Final Report on M551, M552, and M553, Westinghouse, Pittsburgh, Pa., NASA Contract NAS8-28730, NASA-CR-120479 (N74-35249), December 12, 1973, 30 pgs.

Abstract: Strength of adhesion and cohesion of melted metals appears undiminished by zero gravity. Brazing is practical for joining or repairing in space and is tolerant of dimensional gap variation.

(7) Stuhlinger, E., "Project Skylab - Technical Processes Under Weightlessness", Press Briefing at KSC, Nov. 1973.

(8) Green, W. D., "Skylab II - Seeing the Sun in a Different Light - Mission Equipment, Experiments, and Observations", NASA/HDQTS, Astronautics and Aeronautics, Vol. 12, (74A20168), Feb., 1974, 10 pgs.

Abstract: Space manufacturing as a minor topic.

(9) Tobin, J. M., "Research Study on Materials Processing in Space," Experiment Number M512, Special Summary Report on M551, M552, and M553 (Adhesion - Cohesion Phenomena), NASA Contract NAS8-28730 (74-34880), Contractor Number WANL-TME-2850, March, 1974, 26 pgs.

C. SOUNDING ROCKET PLANNING

(1) Martin, R. C., Rocket Payload Non-Spin Platforms, Astro-Space Labs, Huntsville, Alabama, NASA Contract NAS8-30528, Contractor Report No. SDL 8-3-528-MPR-ARR74, April, 1974.

(2) Wuenscher, H. F., "Space Processing on Sounding Rockets", Proceedings of the Third Space Processing Symposium, Vol. II, M-74-5, June, 1974, pgs. 565-579.

Abstract: Summary of ground-based zero-gravity simulation techniques. Characteristics of sounding rockets are discussed.

(3) "Space Processing Rocket Experiment Project", NASA, Announcement of Opportunity No. OA-74-1, November, 1974.

Abstract: Announcement of Opportunity for the NASA Space Processing Applications Rocket Program (SPAR).

(4) Lewis, G., "Apparatus, Techniques and Physical Parameters of Soundin Rocket Flight", Proceedings of ESRO Symposium on Manufacturing and Processing in Space, ESRO SP-101.

(5) Handbook for Space Processing Sounding Rocket Science Payloads, NASA/MSFC, Report No. M-EH-75-2, March, 1975.

Abstract: Handbook provided to assist NASA and associated experimenters and apparatus suppliers to successfully perform SPAR experiments.

(6) Grahn, S., Space Processing Rocket Experiments - Possibilities and Constraints, Facilities in Europe, Swedish Space Corporation, Solna, Sweden, Contractor Report No. E1-8, June, 1975, 19 pgs.

Abstract: A review of the possibilities and constraints of sounding rockets for space processing. The available facilities at Esrange, Sweden and the resources of the Swedish Space Corp. for managing a European sounding rocket program are presented.

Section II.C.

(7) "67° 53', N21° 06'E," Estrange Brochure, Swedish Space Corporation, Solna, Sweden, June, 1975.

Abstract: Publication describing the Swedish sounding rocket launch facilities.

(8) McCreight, L. R., Noone, M. J., Locker, R. J., "Undirectional Solidification Apparatus for Sounding Rockets", GE, Space Science Laboratory, Valley Forge, Pa., Second European Symposium on Materials Sciences in Space, Frascati, Italy, April 6-8, 1976.

Abstract: Discussion of new developed sounding rocket furnaces.

D. SPACE SHUTTLE PLANNING/UTILIZATION

(1) Rose, J. T., "Facilities Planning Approach for the Space Shuttle", MDAC-ED, St. Louis, Missouri, AIAA Space Shuttle Development Testing and Operations Conference, Phoenix, Arizona, AIAA Paper 71-316 (71A24831), March, 1971, 9 pgs.

Abstract: Shuttle ground rules, manufacturing facilities requirements, ground requirements and verification test facilities, operations requirements, and interrelationships.

(2) McCreight, L. R., Griffin, R. N., "Manufacturing in Space - Payloads for the Space Shuttle", GE, Valley Forge, Pa., Space for Mankind's Benefit, Proceedings of the First International Space Congress, Huntsville, Alabama (72A18622), November, 1971, 7 pgs.

Abstract: Float-zone refined semi-conductors, oxide crystals, veral insecticides, vaccines, and biological cells.

(3) Armstrong, W. O., Bredt, J. H., "Status and Plans of NASA's Materials Science and Manufacturing in Space/MS-MS/Program", NASA/HDQTS, Space for Mankind's Benefit, Proceedings of the First International Space Congress, Huntsville, Alabama, (72A18621), November, 1971, 22 pgs.

Abstract: Initiation of a research and development program on the Space Shuttle missions, to prepare for possible commercial manufacturing operations on permanently orbiting space stations.

(4) McCreight, L. R., Griffin, R. M., "Manufacturing in Space - Payloads for the Space Shuttle", GE, Valley Forge, Pa., Space for Mankind's Benefits, Proceedings of the First International Space Congress, Huntsville, Alabama, (72A18622), November, 1971.

(5) Ehricke, K. A., "Use of Shuttle in Establishing Large Space Installations", NAR, Downey California, Space Shuttle Payloads, Proceedings of the Symposium, Washington, D. C., (74A14121), December, 1972, 50 pgs.

Section II.D.

Abstract: Feasibility of orbiting solar reflection and space power generation and distribution plants; space manufacturing.

(6) Hammel, R. L., "Use of Shuttle for Test of Experimental Hardware in Space", TRW, Redondo Beach, Cal., AAS-72 Annual Meeting, Washington, D. C., 1972.

(7) McCreight, L. R., "Use of Shuttle for Manufacturing and Materials Process Experiments in Low-G", GE, Valley Forge, Pa., AAS, Space Shuttle Payloads Session, Vol. 30, Science and Technology, 1973.

Abstract: Space processing without convection or sedimentation and the high intrinsic values of some biologicals and electronic materials may warrant the efforts of space transportation.

(8) Henrici, J., "European Industrial Cooperation in the Space Effort", Messerschmitt - Boelkow Blohm Gmbh, Munich, Germany, Proceedings of the Eleventh Goddard Memorial Symposium, Washingtc , D. C., (74A14471), March 9, 1973, 9 pts.

Abstract: European industrial role in European space program definition and relationship (via ESRO and NASA) with U. S. firms.

(9) Taylor, K. R., et al., "Requirements and Concepts for Space Processing Payloads, Processing and Manufacturing in Space", ESRO SP-101, July, 1974.

(10) Bredt, J. H., et al., Final Report of the Space Shuttle Payload Working Groups, Vol. 9, Materials Processing and Space Manufacturing, NASA Goddard Space Flight Center, May, 1973.

Section II.D.

(11) Culbertson, P. E.. "The Space Shuttle and Its Utilization" NASA/HDQTS, COSPAR, 16th Plenary Meeting, Konstanz, Germany, (73A35936), May 23, 1973, 24 pgs.

Abstract: Shuttle capabilities for satellite delivery, revisit, sortie mission, and delivery to higher orbits with the Tug.

(12) Sivertson, W. E., Jr., "A Shuttle Compatible Advanced Technology Laboratory", NASA/Langley Research Center, AIAA, ASME, and SAE Joint Space Mission Planning and Executive Meeting, Denver, Colorado, (73A36089), AIAA Paper 73-611, July 1973, 11 pgs.

Abstract: Space can routinely be made available to the Langley researcher via the shuttle-compatible spaceborne advanced technology laboratory with sortie flight operation mode.

(13) Mulholland, D. R., Reller, J. O., Jr., Neel, C. B., Haughney, L. C., "Study of Airborne Science Experiment Management Concepts for Application to Space Shuttle", Vol. I, Executive Summary, NASA/Ames Research Center, NASA-TM-X-26688 (74N13570), July, 1973, 23 pgs.

Abstract: Management concepts and operating procedures for shuttle spacelab operations, experimenter involvement, experiment development and data handling.

(14) "Requirements and Concepts for Materials Science and Manufacturing in Space Payload Equipment Study", Vols. I-II, DCN T-2-21-00172.52, July, 1973.

(15) Hammel, R. L., Requirements and Concepts for Materials Science and Manufacturing in Space Payload Equipment Study, TRW, Redondo Beach, Cal., 7 Vols., NASA-CR-120115 to 21 (74X10030 to 36), July, 1973.

Section II.D.

(16) "Shuttle Orbital Applications/Requirements (SOAR) Supplementary Tasks", MDAC-WD, Huntington Beach, CAl., NASA-CR-124431 (N73-32771), September, 1973, 365 pgs.

(17) Naugle, J. E., "Research With the Space Shuttle, NASA/MDQTS, Physics Today, Vol. 26, Nov., 1973, 7 pgs.

(18) Causse, J. P., "The Spacelab Program--Project Conceptualization and Planning", Techtran Corp., Glen Burnie, Maryland, Communication Presentee au 24 eme Congres International D' Astronautique, Bokow, (74A12497), November, 1973, 22 pgs.

Abstract: Spacelab users; shuttle interfaces, crew, models and configurations. Decision to be made by European governments. English translation.

(19) Berge, K. D., Tegtmeier, A., "Spacelab-Europe's Participation in Manned Space Flight and Its Long-Term Aspects," Vesterreichische Gesellschaft Fuer Weltraumforschung and Flugkoerpertechnik and Duetsche Gesellschaft Fuer Luft - and Raumfohrt, 6th Gemeinsame Jahrestagung, Innsbruck, Austria, (74A17182), September, 1973.

(20) "Space Processing Applications Launch Site Operations", TRW Study for NASA/KSC, Part 1 Technical Report, Contract NAS10-8606, December, 1974.

E. SPACE SHUTTLE DESIGN/PAYLOAD INTERFACE

(1) "Proceeding of the Space Shuttle Sortie Workshop, Vol. 2, Working Group Reports", NASA/GSFC, NASA-TM-X-68842 (73N15867), August, 1972, 561 pgs.

Abstract: Mission planning process in many areas including materials processing and space manufacturing. Working group reports.

(2) Marshall, W. R., "Payloads", NASA/MSFC, Space Shuttle Program: Proceedings of the Short Course, Boulder, Colorado, (73A37593), October, 1972, 58 pgs.

Abstract: Payload definition, design and planning techniques in Space Shuttle program.

(3) Payload Analysis for Space Shuttle Applications, Vol. 4, Executive Summary, Aerospace Corporation, El Segundo, Cal., NASA-CR-130025 (73N16872), October 15, 1972, 25 pgs.

Abstract: Final Report 1 October 1971 - 31 August 1972 Payload guidelines for space shuttle/tug.

(4) Sortie-Laboratory Preliminary Definition Study, Requirements and Concepts Report, Messerschmitt-Boelkow-Blohm Gmbh, Ottobrunn, Germany, Contractor Number MBB-LS-72-04 (73N22826), November 15, 1972, 707 pgs.

Abstract: Examination of subsystems resulting in common support system for integrated payload providing standardization and reduced turnaround time.

(5) Sortie Laboratory Preliminary Definition Study, British Aircraft Corporation, Fieton, England, Contractor No. ESS/SS-399 (73N26902-4), Vol. 1-3, November, 1972, 500 pgs.

Abstract: Vol. 1 - Description of shuttle interface, operational analyses of experiment integration. Project and design guidelines given by ESRO are included.
Vol. 2 - Requirement assessment, trade-off studies and resulting preferred concept for each subsystem. Cost effectiveness and flexibility applied to arrive at a preferred configuration.

Section II.E.

Abstract: Vol. 3 - Technological implications, preliminary assessment of system costs, safety aspects, potential system growth (to 6 crew, 30 day mission).

(6) Johnson, R. W., "The European Shuttle Payload Activity," NASA/HDQTS, Space Shuttle Payloads, Proceedings of the Symposium, Washington, D. C., (74A14124), December 1972, 13 pgs.

Abstract: Description of ESRO organization for Space Shuttle payload planning. Evaluation of Sortie Lab design activity.

(7) Heberlig, J. C., "The Space Shuttle System Description, Operations, and Payload Capabilities", NASA/JSC, Space Shuttle Payloads, Proceedings of the Symposium, Washington, D. C., December, 1972, 42 pgs.

Abstract: Characteristics of Space Shuttle System, mission and performance baselines, orbital parameter/payload capability relationships, scientific and applications operating modes.

(8) Morgenthaler, G. W., Bursnall, W. J., MMA, Denver, Colorado, Space Shuttle Payloads, Proceedings of the Symposium, Washington, D. C., AAS Science and Technology Series, Vol. 30, (74A14102), 1973, 509 pgs.

Abstract: Space Shuttle System, payloads and utilization including cost effectiveness.

(9) Tolle, H., Tegtmeier, Wienss, W., "The Modular Space Lab - Results of a European Phase A Study", Technology Today and Tomorrow, Proceedings of the Tenth Space Congress, Cocoa Beach, Florida, (74A16109), April, 1973, 16 pgs.

Abstract: Results of Sortie Lab/Pallet system study. Sponsored by ESRO.

Section II. E.

(10) "Materials Processing and Space Manufacturing", The Space Shuttle Payload Planning Working Groups Final Report, Vol. 9, NASA/GSFC, NASA-TM-X69459 (74N15526), May 1973, 73 pgs.

Abstract: Areas recommended for investigation: effects of weightlessness on levitation, mixture stability, control over heat and mass transport in fluids. Research and development projects: metallurgical and non-metallic materials and processes, electronic materials and biological applications. Payload allocation; experiment acceptance and flight qualification; private use of shuttle.

(11) "Shuttle System Payload Data Activity Plan (SSPDA), GD, Convair Division, San Diego, NASA-CR-133277 (73X78183), Contractor Number GDCA-DDA73-001, Feb. 23, 1973.

(12) Low Cost Payload Design Concepts Study, Lockheed, Sunnyvale, Cal., Vol. 1, 2, Contract NAS8-28960, Contractor Number LMSC8-28960-D336289.

(13) Hatterick, R. G., Development of Flight Experiment Work Performance and Workstation Interface Requirements, URS/Matrix Company, Contract NAS8-29359, NASA-CR-124409 (73N32733), August 31, 1973, 348 pgs.

Abstract: Final Report. Definition of skills required of crew in support of Sortie Lab space shuttle experiments.

(14) "Sortie Laboratory, Phase B, Technical Summary--Design and Operational Requirements", NASA/MSFC, NASA-TM-X69442 (74N11697), Nov., 1973, 200 pgs.

Abstract: Summary of Sortie Lab (SL) analysis, source of systems requirements and experimental support for SL baseline. Configuration definition, mission analysis, experiment integration, safety and logistics.

Section II. E.

(15) "Spacelab--NASA/ESRO Payload of Space Shuttle", Flug Revue/ Flugwelt International,(74A29831), May, 1974, 4 pgs.

Abstract: (In German) Background, research objectives and design of Spacelab.

(16) Taylor, K. R., Hammel, R. L., "Space Processing Payloads for the Space Shuttle Era", 12th AIAA Sciences Meeting, Washington, D. C., AIAA Paper 74-153 (74A18796), Jan. 30, 1974, 13 pgs.

Abstract: Definition of facilities using modular, reusable research equipment in partial and dedicated payloads in Spacelab.

(17) Shapland, D., "Space Science Prepares to Take Off---Skylab Configurations for Spaceborne Experiments, ESRO, Delft, Netherlands, New Scientist, Vol. 6, (74A24652), Feb. 28, 1974, 3 pgs.

Abstract: Spacelab description and potential.

(18) Hammel, R. L.,"Space Processing Payload Equipment Study - A Requirements Overview", TRW, Redondo, Beach, CA, NASA Contract NAS8-31444, Feb., 1976.

Abstract: Space Processing Applications activities in materials science, disciplines - Unique Spacelab and STS requirements.

(19) Shapland, D. J., "Shuttle and Spacelab Capabilities", ESA, Neuilly-sur-Seine, France, Second European Symposium on Material Sciences in Space, Frascati, Italy, April, 1976.

Abstract: Potential of Shuttle-Spacelab combination to future users. Topics covered include attainable flight parameters, mission flexability, data management, user services and programme schedules.

Section II. E.

(2( ) Zimmerman, P., "Accomodation of European Material Science Experiments into Spacelab Payloads", Messerschmitt-Belkow-Blohm Gmbh, Second European Symposium on Material Sciences in Space, Frascati, Italy, April, 1976.

Abstract: Results of pulminary accomodation study for a material science payload which was performed by Messerschmitt - Bolkow - Blohm under ESA direction.

PAGE

SECTION III. FLUID MECHANICS AND HEAT TRANSFER

A. GENERAL FLUID MOTION STUDIES

(1) Brazinsky, I., Weiss, S., A Photographic Study of Liquid, Hydrogen Under Simulated Zero Gravity Conditions, NASA/LRC, NASA-TM-X-479 (62N10095), Feb. 1962, 16 pgs.

Abstract: During three-quarters of a second free-fall in a Dewar, adhesive forces caused liquid to "rise" into original gas space.

(2) Velkoff, H. R., "A New View of Electric Effects on Fluid Dynamics", USAF System Command, 1962 Compendium of Symposium Papers, Vol. 1, (68X8[illegible]04), Sept., 1962, 53 pgs.

Abstract: Some key words: boundary layers, electrical discharges, electrical fields, electrophoresis, fluid dynamics, heat transfer, weightlessness.

(3) Knoll, R. H., Nunamker, R. R., Smolak, G. R., "Weightlessness Experiments with Liquid Hydrogen in Aerobee Sounding Rockets, Uniform Radiant Heat Addition - Flight 1", NASA/LRC, NASA-TM-X-484 (68N83450), June, 1962, 63 pgs.

Abstract: Some key words: heat transfer, radiant heating, saturation, temperature distribution, weightlessness.

(4) Randolph, B. W., "Analytical Program on Zero Gravity and Near-Zero Gravity Hydrodynamics and Heat Transfer in Fluids", Northrop, Hawthorne Cal., NASr-23 (63X11153), October, 1962, 10 pgs.

Abstract: Some key words: camera, cylinder, Euler-Lagrange equation simulator.

(5) Shulkeikin,V. V., "Shape of the Surface of a Liquid in Process of Losing Its Weightiness", NASA, Akademiia Nank SSR, Doklady, Vol. 147, No. 1, Nov. 1, 1962, NASA-TT-F-8373 (63X11449), Jan. 1963, 10 pgs.

Abstract: Translated by Andre L. Brechant
Some key words: cylinder, dynamics, flask, meniscus, pressure, rotation, surface tension, weightlessness, wetting.

Section III.A.

(6) Good, R. J., New, J. T., "Equilibrium Behavior of Fluids in Containers at Zero Gravity", GD, San Diego, Cal., AIAA Journal, Vol.1, (63A15876, 65A19324), April, 1963, 6 pgs.

Abstract: Wall wetting fluids will distribute about the container with vapor centrally located, and can be accumulated in desired volumes by use of baffles. Based on intersurface energy configurations.

(7) Wallner, L. E., Nakanishi, S., "A Study of Liquid Hydrogen in Zero Gravity," NASA/LRC, NASA-TM-X-723 (72N71527), August, 1963, 65 pgs.

Abstract: Some key words: heat transfer, liquid, sloshing, liquid-vapor interfaces.

(8) Swalley, E. E., Wood, C. C., "Research in Support of Zero and Reduced Gravity Fluid Mechanics and Heat Transfer", NASA/MSFC, Zero Gravity Fluid Behavior, 71X82420, Oct., 1963, 6 pgs.

(9) Shulkeikin, V. V., "Earth-Bound Experiments with Weightless Liquids," Akademiia Nauk SSR, Vol. 152, (74Z17071), Oct. 11, 1963, 4 pgs.

Abstract: Ground based experimental apparatus for filming liquid behavior in free fall for 0.9 seconds. Results for water and mercury. Translated from Russian (A6411349).

(10) Liubin, L. IA., Povitskii, A. S., "Emptying and Filling Vessels in Conditions of Weightlessness", Planetary and Space Science, Vol. 11, (64A12692), Nov., 1963, 16 pgs.

Abstract: Three and two dimensional analyses of gas pressure-pulse method; surface tension method of liquid transfer. Translated from Russian (A63-18195).

Section III. A.

(11)Zenekevich, V. B., "Behavior of a Fluid in Zero-Gravity Conditions", Teplofizika Vysokikh Temperatur, Vol W, (64A21777), March, 1964, 8 pgs.

Abstract: (In Russian) Processes occurring in a partially-filled spherical container during transition to zero gravity. (Translation, A65-20539).

(12) "The Fluid Dynamic Aspects of Space Flight", Proceedings of the NATO-AGARD Specialists' Meeting, Marseille, France, (67A14987), April 20, 1964, 402 pgs.

(In English and French)

(13) Good, R. J., New. J. T., "Fluid Behavior in Zero Gravity", GD, San Diego, Cal., AIAA Journal, Vol. 1, April 1963, (65A19324), 1964, 16 pgs.

Abstract: Investigation of equilibrium configuration of fluid in absence of gravity field based on intersurface energy considerations. See also A63-15876.

(14) Benedikt, E. T., Halliburton, R., Hung, F. C., Li, T. C., Propellant Behavior in Zero Gravity, Final Report, NAR, Downey, Cal., NASA-CR-62508 (65X14834), Nov., 1964, 63 pgs.

Abstract: Weightless liquid propellant behavior - dynamics of liquids with a free surface, heat transfer to liquids in motion.

(15) Otto, E. W., "Static and Dynamic Behavior of the Liquid-Vapor Interface During Weightlessness", NASA/LRC, AICE, 55th Symposium, Houston, TX, (65A15228), Feb., 1965, 39 pgs.

Abstract: Survey of liquid-vapor system problem areas and review of related research literature: interface dynamics, pool boiling heat-transfer mechanisms, and evaporation and condensation phenomena.

Section III. A.

(16) Chernoosko, F. L., "Self-Similar Motion of a Liquid Under the Action of Surface Tension", PMM-Journal of Applied Mathematics and Mechanics, Vol. 29, No. 1, (66A28953), 1965, 8 pgs.

Abstract: Effect of surface tension on weightless liquid behavior.

(17) Chernoosko, F. L., Moiseyev, N. N., "Problems of Oscillations of a Fluid Subjected to Surface Tension Forces", NASA-TT-F-10141 (66N27499), May, 1966, 45 pgs.

Abstract: Small linear oscillations of ideal fluid in the presence of surface tension in weightlessness or weak gravitational fields. English translation.

(18) Bouman, T. E., Paynter, H. L., "Weightless Liquids", MMA, Denver, Colorado, Science Journal, Vol. 2, (67A13890), Sept., 1966, 7 pgs.

Abstract: Surface tension and equilibrium surfaces in weightless liquids, with application to spacecraft systems design.

(19) Otto, E.W., "Hydrodynamics of Liquid Surfaces", Selected Technology for the Petroleum Industry, (66N33779), 1966, 21 pgs.

Abstract: Research on dynamic behavior of liquids and gasses in zero gravity flight: drop tower, aircraft, and rocket facilities. Interface statics in cylinders and spheres and with baffles.

(20) Reynolds, W. C., Satterlee, H. M., "Liquid Propellant Behavior at Low and Zero G", LMSC, Sunneyvale, Cal., (67N15898), 1966, 53 pgs.

Abstract: Complex hydrostatic and hydrodynamic behavior of liquids in low and zero gravity, laboratory simulation, and control of weightless liquids.

Section III. A.

(21) Liukin, L. IA., Povitskii, A. S., "Certain Features of the Motion of a Fluid under Weightlessness Conditions", 17th IAF Congress, Madrid, Spain, NASA-TT-F-10868 (67N27521), April,1967, 12 pgs.

Abstract: Effects of weak forces on weightless fluid, filling and emptying vessels and tubes, bubbles in a fluid, absence of convection. English translation.

(22) Clayton, D. A., "Passive Control of a Liquid in a Zero Gravity Environment", Royal Aircraft Establishment, Farnborough, England, RAE-TR-67207 (68N27747), Aug., 1967, 39 pgs.

Abstract: Hydrostatic and hydrodynamic parameters important to liquid propellant altitude control system designers. Preliminary treatment of zero gravity heat transfer.

(23) "Zero-G Liquid Studies - Critical Static and Drop Dynamics", Electro-Optical Systems, Inc., NASA Contract NAS8-21012, NASA-CR-88747 (67N37923), Aug. 1967, 29 pgs.

Abstract: Temperature control, pressure measurement, dynamic behavior, induction in a liquid drop, behavior in electrical and acoustical fields.

(24) Kopachevskii, N. D., "Small Oscillations of an Ideal Liquid in a Vessel Under Close-to-Weightlessness Conditions", Introduction to the Dynamics of Fluid-Containing Bodies Under Conditions of Weightlessness, Vychislitel 'NYI Tsent ANSSR, (69A13811), 1968, 37 pgs.

Abstract: (In Russian) Ideal liquid small oscillations, surface tension, equilibrium conditions and solution by decomposing vector function space.

(25) Bauer, H. F., "Theoretical Investigation of Gas Management in Zero Gravity Space Manufacturing", Georgia Institute of Technology, Contract NAS8-25179, Contractor No. GIT/EES B-910, October, 1970.

Section III. A.

(26) Abdalla, K. L., Otto, E. W., Symons, E. P., Petrash, D. A., "Liquid Transfer Demonstration on Board Apollo 14 During Transearth Orbit", NASA/LRC, NASA-TM-X-2410 (72N11285), Nov., 1971, 31 pgs.

Abstract: Hand pump transferred liquids between surface tension baffled tanks within two percent of liquid residual design value without gas ingestion.

(27) Miller, K. I., "A Summary of Liquid State Models for Materials Processing in Space", Boeing, Huntsville, AL, Contract NAS8-28664, D5-17268, August, 1972.

(28) Otto, G. H., Lacy, L. L., "Quick-Look Report on Skylab 3 Science Demonstration SD-16: Ice Melting", NASA/MSFC/SSL, November, 1973.

(29) Bourgeois, S. V. Brashears, M. R. Fluid Dynamics and Kinematics of Molton Metals in The Low-Gravity Environment of Skylab, NASA Contract NAS8-27015 (74A18860), Jan., 1974.

(30) Grodzka, P. G., Bannister, T. C., "Natural Convection in Low-G Environments", 12th AIAA Aerospace Sciences Meeting, Washington, D. C., AIAA Paper 74-156, Jan. 30, 1974, 12 pgs.

Abstract: In low-g environments, convective driving forces other than gravity will be comparable or predominant importance. Convections driven by steady low-g accelerations, g -jitter, internal thermal volume expansions, surface tension and interfacial tension, electric field, and liquid/solid phase change are covered.

(31) Bannister, T. C., "Skylab III and IV Science Demonstrations", Preliminary Report, NASA/MSFC, NASA-TMX-64835, March, 1974, 26 pgs.

Section III. A.

Abstract: Twelve MSFC science demonstration preliminary results are presented. Most of these demonstrations dealt with fluid motion in low-g.

(32) Grodzka, P. G., Bourgeois, S. V., Brashears, M. R., Spradley, L. W., "Fluid Motion in a Low-G Environment", Third Space Processing Symposium, M-74-5 , June, 1974, pgs. 691-729.

Abstract: The state of knowledge of fluid motions in low-g environments is reviewed and the dimensional analysis approach used to assess the relative importances of various driving forces for fluid flow in four of the Skylab experiments is outlined. Space data is compared to dimensional analyses results.

(33) Gibson, E. G., "Skylab Fluid Mechanics Demonstrations", Lecture, International Colloquium on Drops and Bubbles, California Institute of Technology, Aug. 1974.

(34) Darbo, W., "Liquid Film Demonstration Experiment - Skylab SL-4", NASA/MSFC/SSL, NASA-TM-X-64911, Jan. 1975, 28 pgs.

Abstract: Skylab liquid film demonstration results are presented. Also discussed are 1-g acceleration experiments in which the unprovoked rupture of films was photographed and a mathematical discussion regarding minimal surfaces, and isoperimatic problem, and liquid films.

(35) Klett, M. G., and S. V. Bourgeois, "Analysis of Skylab IV Fluid Mechanic Science Demonstrations", Paper 75-693, AIAA 10th Thermophysics Conference, 27-29 May 1975, Denver.

(36) Grodzka, P. G., Bourgeois, S. V., Facemire, B., Science Demonstrations Aboard Apollo-Soyuz: Chemical Foams and Liquid Spreading, Preliminary Report, LMSC, Huntsville, AL, Nov., 1975, 30 pgs.

Abstract: Data analysis of two ASTP demonstrations.

Section III. A.

(37) Bourgeois, S. V., "Buoyant and Capillary Natural Convection in Infinite Horizontal Liquid Layers Heated Laterally", LMSC, Huntsville, AL, NASA Contract NAS8-27015, Letters in Heat and Mass Transfer, Vol. 2, No. 3, 1975, pgs. 223-236.

Abstract: Solutions for equations describing natural convection in a planar, horizontal layer of liquid with a constant linear temperature gradient along the unbounded top and bottom surfaces. Results are compared to earlier analyses for unbounded liquid layers and applied to low-g solidification.

(38) Padday, J. F., "Capillary Forces and Stability in Zero Gravity Environment", Kodak, United Kingdom, Second European Symposium on Material Sciences in Space, Frascati, Italy, April. 1976.

Abstract: In the absence of gravity, it is shown that certain types of menisci lend themselves to estimating the magnitude and variation of long-range forces. Paper presents theoretical approach to an experiment proposed for operation in zero-gravity environment.

(39) Haynes, J. M., "Capillary Instabilities in 1-g and 0-g", University of Bistrol, United Kingdom, Second European Symposium on Material Sciences in Space, Frascati, Italy, April, 1976.

Abstract: Capillary hystersis in the equilibrium behavior of fluids in porous media demonstrates that equilibrium is reached via a thermodynamically irreversible process.

(40) Schafer, C. F., "Liquid Mixing Experiment", NASA/MSFC, SPAR I Rocket Experiment Report, April, 1976.

Abstract: Preliminary results of SPAR I experiment 74-18.

B. GENERAL HEAT TRANSFER STUDIES

(1) Papell, S. S., "An Instability Effect on Two-Phase Heat Transfer for Subcooled Water Flowing under Conditions of Zero Gravity", NASA/LRC, American Rocket Society Conference, Santa Monica, Cal., ARS Paper 62-2548 (63A11725), September, 1962, 10 pgs.

(2) Adelburg, M., "Effect of Gravity Upon Nucleate Boiling", Arthur D. Little, Inc., Santa Monica, Cal., 2nd AAS Symposium Proceedings, Los Angeles, Cal., (63A23694), January 18, 1963, 27 pgs.

Abstract: Basic forces that influence nucleate-boiling heat transfer at zero gravity, with brief literature survey.

(3) Steinle, H. F., "Review of Zero-G Studies Performed at GDC", GD, San Diego, Cal., 2nd AAS Symposium Proceedings, (63A23689), Jan. 18, 1963, 21 pgs.

Abstract: Review of zero gravity research, specializing in cryogenic liquid behavior, including venting, heat transfer and instrumentation performance.

(4) Gebhart, B., "Random Convection Under Conditions of Weightlessness", Cornell University, AIAA Journal, Vol. 1, (63A13735), Feb., 1963, 4 pgs.

Abstract: Analysis of the heat conduction and vapor condensation between a fluid and its enclosing surface under conditions of weightlessness.

(5) Adelburg, M., "Zero Gravity Heat Transfer", Arthur D. Little Inc., Proceedings of the Annual Technical Meeting of the Institute of Environment Sciences, Mt. Prospect, Illinois, (63A18340), 1963, 8 pgs.

Abstract: Basic forces that influence nucleate-boiling heat transfer at zero gravity.

Section III. B.

(6) Hedgepeth, L. M., Zara, E. A., "Zero Gravity Pool Boiling", Aeronautical Systems Div., Wright-Patterson AFB, Ohio, Science and Engineering Symposium, (64X16087), Sept. 1963, 36 pgs.

Abstract: Nucleate pool boiling in near zero gravity environment.

(7) Bailey, R. V., McGrew, J. L., Murphy, D. W., "Boiling Heat Transfer in a Zero Gravity Envliroment", NAA, Denver, Colorado, Air Transport and Space Meeting, SAE, New York, (64A20299), April, 1964, 32 pgs.

Abstract: Bubble migration in zero and normal gravity. Drop tower study of surface tension effects.

(8) Mechlenburg, K. R., "Materials Research for Heat Transfer Fluids", Midwest Research Institute, Technical Documentary, Report - 1964, Wright-Patterson AFB, (65X17210), April, 1965, 51 pgs.

Abstract: Magnitude of heat transfer coefficient of sodium condensation and electrophoresis for lubricant coatings on complex shapes.

(9) Feldmanis, C. J., "Pressure and Temperature Changes in Closed Loop Forced Convection Boiling and Condensing Processes Under Zero Gravity Conditions", Air Force Systems Command, Wright Patterson AFB, Ohio, (66X12353), Oct.,1965, 22 pgs.

(10) Gurevich, I. G., Kondrashov, Zhuk, I. P., "Non-Stationary Heat and Mass Transfer", Israel Program for Scientific Translations, Ltd., Jerusaleum, NASA-TT-F-432 (67N22041), 1967, 163 pgs.

Abstract: Nineteen articles. Experimental and numerical analyses of unsteady state heat and mass transfer. Soret coefficient.

Section III. B.

(11) Siegal, R., "Effects of Reduced Gravity on Heat Transfer", NASA/LRC, Advances in Heat Transfer, Vol. 4, (68A11371), 1967, 92 pgs.

Abstract: Free and forced convection, boiling, condensation, forced flow and fuel combustion.

(12) Edwards, D. K., "Rotation-Induced, Free-Convection Heat Transfer in a Zero-Gravity Field", UCLA, AIAA Journal, Vol. 5, (67A18864), Feb., 1967, 2 pgs.

Abstract: Free convective heat transfer between hot and cold rotating disks in laminar steady azimuthally symmetric flow in a zero-gravity field.

(13) Larkin, B. K., "Heat Flow to a Confined Fluid in Zero Gravity", MMA, Denver, Colorado, Progress in Astronautics and Aeronautics, Vol. 20, AIAA Paper 67-337 (68A21373), April, 1967, 14 pgs.

Abstract: Momentum, continuity, and energy equations for one dimensional heat flow to a confined ideal gas are solved numerically. Thermal gradients induced accoustical fluid motion.

(14) Liubin, L. IA., Povitskii, S. A., "Effect of Oscillations on Transfer Processes Under Conditions of Weightlessness", Kosmicheskie Issledovaniaa, Vol. 5, (68A16833), Dec. 1967, 9 pgs.

Abstract: (In Russian) Vibrations in absence of forced circulation produce higher heat and mass transfer than molecular transfer mechanism under conditions of weightlessness.

(15) de Lancey, G. B., "An Analysis of Non-isothermal Multicomponent Diffusions in the Liquid Phase", University of Pittsburgh, Pa., (69N20900), 1967, 276 pgs.

Abstract: Coupled heat and mass transfer equations for non-reactive chemical systems are analyzed.

Section III. B.

(16) Boulay, J. L., "Heat Transfer in Liquid Nitrogen in a Zero-Gravity Field," Paris University, ONERA-P-122 (69N22879), 1968, 56 pgs.

Abstract: (In French) Heat flux variation in boiling processes is a function of gravity. Experimental results from three second exposures are compared to theoretical predictions.

(17) McGrew, J. L., "An Investigation of the Effect of Temperature Induced Surface Tension Gradients on Bubble Mechanics and Boiling Heat Transfer," Denver, University, (69N22032), 1968, 104 pgs.

Abstract: Surface tension gradient effect is important in bubble motion and boiling in zero gravity.

(18) Aladev, I. T., Ulianov, A. F., "Experimental Study of Heat Transfer During Boiling in Conduits During Weightlessness", Cosmic Research, Vol. 6, (69A11313), Mar., 1968, 6 pgs.

Abstract: Translation from Russian. Equipment and procedure for studying heat transfer during boiling under short term weightlessness. Water boiling on flat plates in a cylindrical channel at 0.02 to 0.34 m/sec.

(19) Smith, G. V., Forbes, R. E., "Effects of Random Vibration on Natural Convective Heat Transfer in Rectangular Enclosures", Augmentation of Convective Heat and Mass Transfer, ASME, N. Y., 1970, pg. 158.

(20) Pak, H. Y., Winter, E. R. F., Schoenals, R. J., "Convection Heat Transfer in a Contained Fluid Subjected to Vibration", Augmentation of Convective Heat Transfer, ASME, N. Y., 1970, pg. 148.

(21) Margrave, J. L., "Thermodynamic Properties of Liquid Metals - A Review", Rice University, Houston, TX, High Temperatures - High Pressures, Vol. 2, No. 6, NSG-659 (72A34000), 1970, 4 pgs.

Section III. B.

Abstract: Summary of thermodynamic properties of liquid metals, heats of fusion and heat capacities.

(22) Henry, H. R., "Two Phase Flow and Heat Transfer in Porous Beds Under Variable Body Forces", UA, Tuscaloosa, AL, Contract NAS8-21143, NASA-CR-121056 (72N12227), May, 1970, 72 pgs.

Abstract: Experiment design, materials selection, and identification of system elements requiring further development.

(23) Benefield, J. W., Heat Flow and Convection Demonstration, NASA-CR-119948 (X71-10975), August, 1971.

(24) Littles, J. W., Merte, H., Jr., "Zero Gravity Incipient Boiling Heat Transfer", NASA/MSFC, University of Michigan, Space Transportation System Propulsion Technology Conference, Vol. 4., (71N29612), April, 1971, 38 pgs.

Abstract: Procedure for computing pressure rise in a closed cylindrical container due to side wall heat flux.

(25) Grodzka, P. G., Fan, C., Hedden, R. O., "The Apollo 14 Heat Flow and Convection Demonstration Experiments: Final Results of Data Analyses," LMSC, Huntsville, AL, NASA Contract NAS8-25577, NASA-CR-19960 (X71010971), Sept.1971.

(26) Povitskii, A. S., Liubin, L. JA., "Fundamentals of the Dynamics and Heat and Mass Transfer of Fluids Under Conditions of Weightlessness", Izdatel 'Stvo Mashinostroenie. 73A35868, 1972, 252 pgs.

Abstract: (In Russian) Blow gas extraction of fluids from tanks, vibration enhanced transport, analysis of bubble and droplet motion, steady and unsteady viscous flows in slots with non-paralled walls.

Section III. B.

(27) Grodzka, P. G., Bannister, T. C., "Heat Flow and Convection Demonstration Experiments Aboard Apollo 14", Science, Vol. 176, May, 1972, pgs. 506-508.

Abstract: Flow deservations and thermal data of Apollo 14 experiments have shown that: (i) there are, as expected, convective motions caused by surface tension gradients in a plane liquid layer with a free upper surface, (ii) heat flow in enclosed liquids and gases occurs mainly by diffusive heat conduction, (iii) some convective processes add to heat transfer.

(28) Bannister, T. C., Heat Flow and Convection Demonstration (Apollo 14), NASA/MSFC, NASA-TM-X64735, March 29, 1973.

(29) Grodzka, P. G., Types of Natural Convection in Space Manufacturing Processes, LMSC, Huntsville, AL, NASA-CR-124184 (73X10208), Jan., 1973.

(30) Bannister, T. C., Grodzka, P. G., et al., Apollo 17 Heat Flow and Convection Experiments: Final Results of Data Analyses, Contract NAS8-25577, NASA-TM-X-64772 (N73-31840), July, 1973.

(31) Bannister, T. C., Grodzka, P. G., Heat Flow and Convection Demonstration Experiments Aboard Apollo 14 and Apollo 17, 24th IAF Congress, Baku, USSR, October, 1973.

Abstract: Results of Apollo 14 and 17 demonstrations are analyzed - two types of low-g natural convection.

(32) Williamson, K. D., Jr., Edeskuty, F. J., Taylor, J. F., "Rocket-Borne, Low Gravity Cryogenic Heat Transfer Experiment", Los Alamos Corporation, New Mexico, 7th Space Simulation Conference of AIAA/NSA/ASTM/IES, (74N18559), Nov., 1974, 9 pgs.

Abstract: Steady state data on nucleate boiling heat transfer in nearly zero gravity liquid helium.

Section III. B.

(33) Khamadov, A., "Investigation of Heat and Mass Transfer in Evaporation Under Conditions of Free Convection--In a Solar Heat Engine", Akademiia Nank Teukmenoskii SSR, Fiziko-Tekhnicheskii Institute, (74A29420), 1974, 4 pgs.

Abstract: Simplified expressions neglecting Soret Coefficient, the Dufour effect and friction.

(34) Grodzka, P. G., Bannister, T. C., "Heat Flow and Convection Experiments Aboard Apollo 17", Science, Vol. 187, 1975, pgs. 165-167.

(35) Dodge, F. T., et al., "Thermophysics and Heat Transfer Experiments in Space", Southwest Research Institute Report No. NASA-CR-13472, 1975.

(36) Langbein, D., "Heat Flow, Diffusion and Convection in the Travelling Solvent Method", Battelle - Institue e.v., Frankfurt-am-Main, Germany, Second European Symposium on Material Sciences in Space, Frascati, Italy, April, 1976.

Abstract: The equations describing heat and particle flow during crystal growth by the travelling solvent method are described.

(37) Otto, G. H. and Lacy, L. L., "Observation of the Liquid/Solid Interface in Low-Gravity Melting," UAH, NASA/MSFC, AIAA/AGU Conference on Scientific Experiments of Skylab, Huntsville, AL, AIAA Paper 74-1243, November 1, 1976.

C. CONVECTION STUDIES

1. GENERAL

(1) Zenkovskaia, S. M., "Investigation of Convection in a Layer of Fluid in the Presence of Vibration Forces", Isv. Akad. Nauk SSSR, M ZhG, Vol. 5, 1966.

(2) Zenkovskaia, S. M., "Study of Convection in a Fluid Layer in the Presence of Vibrating Forces", Isv. Akad, Nauk SSSR, Vol. 3, No. 1, 1968.

(3) Faessler, A., "The Behavior of a Burning Candle in Gravitationless Space", Naturivissen Schaften, W. Berlin, Vol. 51, No. 23, 1964, Translation Consultants, Arlington, VA, NASA-TT-F-13940 (71N36356), Sept. 1971, 10 pgs.

Abstract: Two experimental arrangements eliminate the effect of continued air circulation due to inertia. A procedure is proposed for a wickless flame experiment.

(4) Lands, J. F., Jr., Ried, R. C., Jr., "Zero Gravity Transient Thermal Mixing Simulation", NASA/JSC, MSC Cryogenic Symposium Papers, (72N23798), May, 1971, 26 pgs.

Abstract: Experimental simulation via analogy between unsteady heat conduction and species diffusion, extended also to include cubical tank geometry. Thermal mixing in Apollo Service Module cryogenic oxygen storage system.

(5) "Apollo 14 Mission Report, Supplement 7 - Inflight Demonstrations", NASA/JSC, NASA-TM-X-68691 (72N28818), NASA-TM-X2410, NASA-TM-X-64611, NASA-TM-X64641, Jan. 1972, 284 pgs.

Abstract: Liquid transfer, electrophoresis, composite casting and heat flow and convection experiments are reviewed.

(6) Bourgeois, S. V., Grodzka, P. G., "Convection in Space Processing (M512)", Phase A Report, LMSC, Huntsville, AL, NASA-CR-127909 (72X79279), July, 1972.

Section III. C. 1.

(7) Masubuchi, K. Muraki, T., "Phase A of Thermal Analysis of M551 Through M554 Experiments for Materials Processing in Space", MIT, Cambridge, Mass., Contract NAS8-28732, Contractor No. MIT-8-28732-FR-Ph.A, July 25, 1972.

(8) Fan, C., "Convection Phenomena in Electrophoresis Separation", LMSC, Huntsville, AL, NASA-CR-124058 (73X10120), Dec. 1972.

(9) Grodzka, P. G., "Types of Natural Convection in Space Manufacturing Processes", LMSC, Huntsville, AL, NASA-CR-124184 (73X10208), Jan., 1973.

(10) Bannister, T. C., "Heat Flow and Convection Demonstration (Apollo 14)", NASA/MSFC, NASA-TM-X-64735 (73N27797), March, 1973, 139 pgs.

Abstract: In less than 0.000001 g, data indicate 1) surface tension gradients produce convective motion; 2) heat flow in fluids is mainly by diffusive conduction; and 3) some convection (characteristics unknown) increases heat transfer.

(11) Spradley, L. W., Bourgeois, S. V., Fan, C. F., Grodzka, P. G., "A Numerical Solution for Thermoacoustic Convection of Fluids in Low Gravity", LMSC, Huntsville, AL, NASA-CR-2269 (N73026289), May, 1973, 90 pgs.

Abstract: A finite difference technique for solving the differential equations for thermal convection of compressible fluids in low gravity. One-dimensional radial model of Apollo 14 heat flow and convection experiment.

(12) Bourgeois, S. V., "Convection in Skylab M512 Experiments: M551, M552, and M553", Phase B Report, LMSC, Huntsville, AL, NASA-CR-12439 (73-28852), July 15, 1973, 75 pgs.

Abstract: Convection of molten metals and their solidification in reduced gravity.

Section III. C. 1.

(13) Bannister, T. C., Grodzka, P. G., Spradley, L. W., Bourgeois, S. V., Hedden, B. O. Facemire, B. R., "Apollo 17 Heat Flow and Convection Experiments: Final Results of Data Analysis", LMSC, Huntsville, AL, NASA-TM-X-64772 (N73-31840), July, 16, 1973, 164 pgs.

Abstract: Cellular, surface tension-driven convection and convection in confined fluids caused by spacecraft and astronaut movements.

(14) "Study of MS/MS Convection Analysis", LMSC, Huntsville, AL, Contract NAS8-29610, Contractor No. LMSC/HREC 8-29610-Bi MPR Aug. 73, August, 1973.

(15) Bourgeois, S. V., "Convection Effects on Skylab Experiments, M551, M552, M553", Phase C Report, Contract Report NAS8-27015, Contractor Number LMSC/HREC-TR-D306955, Dec. 1, 1973.

(16) Grodzka, P. G., Bannister, T. C., "Natural Convection in Low-G Environments", LMSC, Huntsville, AL, AIAA Paper No. 74-156, 12th AIAA Aerospace Sciences Meeting, Washington, D. C., Jan., 1974.

(17) Spradley, L. W., "Thermoacoustic Convection of Fluids in Low Gravity", LMSC, Huntsville, AL, AIAA Paper 74-76, Jan. 1974.

(18) Bourgeois, S. V., McDermit, J. H., Spradley, L. W., "Space Processing Applications - Space Convection Analysis", LMSC, Huntsville, AL, NASA Contract NAS8-29610, Contractor No. LSMC-HREC-TR-D390825, May, 1975, 89 pgs.

Abstract: The modes and driving forces of natural convection in space are examined. Design consideration are advanced to minimize detrimental effects due to convection in microgravity.

(19) Spradley, L. W. Bourgeois, S. V., "Space Processing Convection Evaluation: G-Jitter Convection of Confined Fluids in Low Gravity", LMSC, Huntsville, AL, 10th Annual Thermophysics Conference, Denver, Colorado, AIAA Paper 75-695, May, 1975, 14 pgs.

Section III. C. 1.

Abstract: G-jitter convection, caused by time-varying accelerations imparted on a heated container of fluid in low gravity is analytically investigated.

(20) Wilcox, W. R., Chang, C. E., "Thermocapillary Convection in Floating Zone Melting", USC, Third American Conference on Crystal Growth, Stanford, Cal., July 14, 1975.

(21) Bourgeois, S. V., Spradley, L. W., "Skylab M518 Multipurpose Furnace Convection Analysis", LMSC, Huntsville, AL, Contract NAS8-27015, Contractor No. LMSC-HREC TR D496534, Sept., 1975, 64 pgs.

Abstract: Theoretical analysis of convection present in ground tests and Skylab processing of experiments M556, M559, M560 and M562.

(22) Ostrach, S., "Convection at Reduced Gravity", Case Western Reserve University, Cleveland, Ohio, Second European Symposium on Material Sciences in Space, Frascati, Italy April, 1976.

Abstract: Various modes of flow possible with the driving forces. Criteria for determining the extent and nature of the resulting flows and heat transfer.

2. THERMODIFFUSION

(1) Farber, M, Libby, W. F., "Effect of Gravitational Field on the Thermal Diffusion Separation Method", Journal of Chemical and Physics, Vol. 8., 1940, pgs. 965-969.

(2) Tilvis, E., "Thermal Diffusion in Liquids in a Rotating System", Society Scient. Fenn. Comment. Phys. - Math, Vol. 13, No. 15, 1947, pgs. 3-59.

(3) Tyrell, H. J. V., Colledge, R., "Thermal Diffusion Potentials and the Soret Effect", Nature, Vol. 173, Feb. 1959, pgs. 264-265.

Section III. C. 2.

(4) Ito, R., Mizushina, T., "Analysis of the Unsteady State in the Thermal Diffusion Cell", Mound Laboratories, Miamisburg, Ohio, (64N13343), Oct., 1963, 17 pgs.

Abstract: Translated into English. Exact solution for measuring the coefficient of ordinary diffusion and the Soret coefficient in experiments of short duration.

(5) Braski, D. N., O'Donnell, F. R., Kobisk, E. H., Progress Report on Specimen Fabrication and Ground Tests for NASA Skylab Experiment M-558, ORNL TM-4152, April, 1973.

(6) Yeh, H. M., Cheny, S. M., "A Study on the Separation Efficiency of Rotary Thermal Diffusion Columns", Chemical Engr. Sci., Vol. 28, 1973, pgs 1803-1808.

(7) Braski, D. H., Kobisk, E. H., "Radioactive Tracer Analysis of Flight Samples from Skylab Experiment M558", Oak Ridge Labs, Tenn. Contract W-7405-eng-26, Final Report, Feb., 1974, 19 pgs.

(8) Braski, D. H., Kobisk. E. H., O'Donnell, F. R."Preparation, Testing and Analysis of Zinc Diffusion Samples -M558", Oak Ridge Labs, Tenn., Contract W-7405-eng-26, April, 1974, 58 pgs.

(9) Ukanwa, A. O., "M558 Radioactive Tracer Diffusion", Howard University, Washington, D. C., Proceedings of the Third Space Processing Symposium: Skylab Results, Vol. I, M-745, June, 1974, pgs. 428-457.

Abstract: Review of preliminary results of Skylab experiment M558 measurements of self-diffusion and impurity diffusion effects in liquid metals.

(10) Maljac, Y., "Review of Possible Eutectic Alloy and Thermo-difussion Experiments", French Atomic Energy Commission, Grenoble, France, Second European Symposium on Material Sciences in Space, Frascati, Italy, April, 1976.

Section III. C. 2.

Abstract: Definition of future research programs based on Skylab and ASTP experiment results.

3. MARANGONI CONVECTION

(1) Scriven, L. E.,Sternling,C. V., "On Cellular Convection Driven by Surface Tension Gradients: Effects of Mean Surface Temperature and Surface Viscosity", Journal of Fluid Mechanics, Vol. 19, 1964, p. 321.

(2) Debler, W. R., Wolf, L. W., "The Effects of Gravity and Surface Tension Gradients in Fluid Layers with Parabolic Temperature Profiles", Journal of Heat Transfer, Vol. 92, No. 3, 1970, p. 351.

(3) Dragoo, A. L., Paule, R. C., "Ultrapure Materials - Containerless Evaporation and the Roles of Diffusion and Marangoni Convection", National Bureau of Standards, Washington, D. C., 12th Annual AIAA Aerospace Sciences Meeting, Washington, D. C., AIAA Paper 74-209 (74A18861), Jan. 1974, 9 pgs.

Abstract: Thermodynamic calculations including complex chemical equilibria of impurity evaporation. Estimations of effect of diffusion and convection on mass transfer rates. Calculations for evaporative purification of molten alumina.

(4) Reed, R. E., "Progress Report on Apollo-Soyuz Test Project Experiment No. MA-041 for Sept. 1 - Dec. 31, 1974", Oak Ridge Labs, Tenn. ORNL-TM-4842, Contract W-7405-eng-26, April, 1975.

(5) Lefever, R. A., Chang, C. E., Wilcox, W. R., "Surface Tension Driven Convection in InSb-GaSb Melts Solidified Aboard Skylab III", American Physical Society, Pasadena, CA, Dec., 1975.

Section III. C. 3.

(6) Beck, R., Grus, K., Segev, G., "Observations, Estimates and Suggested Experiments Relating to Surface - Tension Induced Thermoconvection", Battelle Institut e.v., Frandfurt-am-Main, Germany, Second European Symposium on Materials Sciences in Space, Frascati, Italy, April, 1976.

Abstract: Theoretical considerations and experiments proposed to measure the temperature dependence of the surface tension and the motions in the melt.

4. CONVECTIVE EFFECTS

(1) Catton, I., "Effect of a gravity Gradient on Free Convection from a Vertical Plate", AIChE Chem. Engr. Progr. Symp. Series, Vol. 64, No. 82, 1968.

(2) Grodzka, P. G., "Gravity - Driven and Surface Tension - Driven Convection in Single Crystal Growth", LMSC, Huntsville, AL, (70N14678), Feb. 5, 1970, 15 pgs.

Abstract: Analytical and mathematical studies of floating zone and Czochralski techniques of single crystal growth.

(3) Parker, R. S., Dragoo, A. L., "Investigation of Convective Effects and Crystal Growth", National Bureau of Standards, Washington, D. C., Contract No. W-13475, July, 1972.

(4) Bourgeois, S. V., "Convection Effects on Skylab Experiments M551, M552, and M552 Phase C Report", LMSC, Huntsville, AL, Contractor Report LMSC-HREC TR D306955, Dec. 1973, p. 68.

(5) Bourgeois, S. V., "Convection Effects on Skylab Experiment M566", LMSC, Huntsville, AL, LMSC-HREC TR D390330, July, 1974, p. 7.

(6) Carruthers, J. R., "Origins of Convective Temperature Oscillations in Crystal Growth", Bell Labs. Murray Hill, N. J., Journal of Crystal Growth, 1975.

D. LIQUID FLOATING ZONE

(1) Keck, P. H., Green, M., Polk, M. L., "Shapes of Floating Liquid Zones Between Solid Rods", Journal of Applied Physics, Vol. 24, No. 12, 1953, pgs. 1479-1481.

(2) Carruthers, J. R., Grasso, M., "The Stabilities of Floating Liquid Zones in Simulated Zero Gravity", Bell Labs, Murray Hill, N. J., Crystal Growth, Vols. 13/14, 1972 pgs. 611-614.

(3) Carruthers, J. R., "Studies of Liquid Floating Zones on SL-IV, The Third Skylab Mission", Bell Labs, Murray Hill, N. J., Proceedings of the Third Space Processing Symposium: Skylab Results, Vol. II, M-74-5, June, 1974, pgs. 837-857.

(4) Fowle, A. A. Haggerty, J. S., "Float-Zone Processing in a Weightless Environment", Arthur D. Little, Cambridge, Mass., NASA Contract NAS8-29877, Contractor Report No. Little 8-29877-BiMR-1, March 18, 1974.

(5) Klett, M. G., "Analysis of Skylab in Liquid Floating Zone Experiments", LMSC, Huntsville, AL, NASA Contract NAS8-27015, Contractor Report No. LMSC-HREC TM D3906913, Feb., 1975, 41 pgs.

Abstract: Analysis of the Skylab liquid floating zone experiment data to examine the stability constraints in low-gravity for application to Shuttle - era processes.

(6) Carruthers, J. R., Gibson, E. G., Klett, M. G. Facemire, B.R., "Studies of Rotating Liquid Floating Zones on Skylab IV," 10th Thermophysics Conference, Denver, Colorado, AIAA Paper 75-692, 7 pgs.

Abstract: Liquid floating zones studies on Skylab are of interest in the containerless handling of melts for possible future space processing crystal growth experiments. Three basic types of zone deformation and instability were observed and analyzed for the rotational modes used.

Section III. D.

(7) Wuest, W., Fluid Dynamics of the Floating Zone", DFVLR - Institut fur Dynamik Verdunnter Gase, Gottingen, Germany, Second European Symposium on Material Sciences in Space, Frascati, Italy, April, 1976.

Abstract: Four aspects of fluid dynamics of floating zones are considered.

(8) Herranz. I. M., "Floating Zone Under Reduced Gravity Axi-Symmetric Equilibrium Shapes", Laboratorio de Aerodynamica, Madrid, Spain, Second European Space Symposium on Material Sciences in Space, Frascati, Italy, April, 1976.

Abstract: The mathematical formulation of the problem of caluclating the axi-symmetric equilibrium shapes of an incompressible fluid mass, held by surface tension forces between two parallel coaxial discs, and rotating about its axis, is considered.

(9) Da-Riva, I., Ruesga, J. M., "Fluids Physics Module Experiments", Laboratorio de Aerodynamica, Madrid, Spain, Second European Symposium on Material Sciences in Space, Frascati, Italy, April, 1976.

Abstract: Review of some zero-gravity experiments concerning floating liquid zones is presented.

E. APPLICATIONS

(1) Wood, C. C., "Evaluation of Experimental and Analytical Data for Orbital Refueling Systems", NASA/MSFC, 5th Propulsion Joint Specialist Conference, AIAA Paper 69-566, (69A32755), June, 1969, 12 pgs.

Abstract: Validity and limitations of applying transient data to low-gravity fluid behavior. Proposes an orbital fluid transfer experiment.

(2) Bauer, H. F., Siekmann, J., "Theoretical Investigation of Gas Management in Zero-Gravity Space Manufacturing", Georgia Institute of Technology, Atlanta, Georgia, NASA/MSFC, Space Processing and Manufacturing Meeting, (70N20537), Feb., 1970, 4 pgs.

Abstract: Degassing and gas distribution in liquified materials in zero-gravity manufacturing.

(3) Mookerji, T., McAnelly, W. B., McKannon, E. C., "Effect of Gravity on Liquid Phase Sintering", Teledyne Brown Engineering, Huntsville, AL, Proceecings of the Third Space Processing Symposium, Vol. II, M-74-5, June, 1974, pgs. 963-1003.

Abstract: Wetting of the solid phase by the liquid during sintering is an important phenomenon in liquid phase sintering, and gravity has influence on both capillary phenomenon and density segregation.

(4) Carruthers, J. R., "The Application of Drops and b les to the Science of Space Processing of Materials" -ll Labs, Murray Hill, N. J., Lecture - International Co. quium on Drops and Bubbles, California Institute of Technology, Aug., 1974.

Abstract: A renewed interest in the dynamic behavior of liquid drops and bubbles has resulted from their importance in the space processing of molten materials. Anticipated configurations and problems for crystal growth and solidification in zero gravity are discussed in light of the current state of knowledge of drop and bubble dynamics.

Section III. E.

(5) Jones, T. B., "Application of Electrohydrodynamic Phenomena to Space Processing", Colorado State University, Colorado, Final Report, NASA Contract NAS8-30250, Contractor Report No. CSU9-3-250-MPL-1, March, 1975, 70 pgs.

Abstract: Study of potential application of low-gravity electrohydrodynamic effects and associated unique fluid handling capabilities to space processing.

(6) Belouet, C., "Fluid Dynamics Problems Connected with Crystal Growth", Laboratories d'Electronique et de Physique Applique'e, Lun eil - Bre'vannes, France, Second European Symposium on Material Sciences in Space, Frascati, Italy, April, 1976.

Abstract: Crystal perfection in space as a function of fluid and mass transports.

(7) Siekmann, J., "Shaping and Degassing of Liquified Matter Under Simulated Low and Zero Gravity", Institut fur Mechanik Technisdre Hochsehule Darmstadt, Germany, Second European Symposium on Material Sciences in Space, Frascati, Italy, April, 1976.

Abstract: Studies on equilibrium figures of an isolated dielectric, non-conducting liquid drop, surrounded by another fluid, are considered as a method of manipulation and control of a weightless melt.

PAGE

SECTION IV. SOLIDIFICATION PROCESSES

A. SOLIDIFICATION STUDIES

1. GENERAL

(1) Pollock, J. T.A., Wald, F., "Directional Solidification of Multicomponent Superconducting Systems under Zero G Conditions", Tyco Labs, Waltham, Mass., NASA/MSFC Space Processing and Manufacturing Meeting, (70N14657), Oct., 1969, 11 pgs.

Abstract: Preparation of stable superconducting cables comprising a filamentary phase of one superconducting in a matrix of another, achieved by directional solidification under zero gravity.

(2) Abbott, R., Fabiniak, R., Fabiniak, T., McKannon, E., "Theoretical Considerations for Liquid Phase Sintering and Solidification in the Space Environment", Cornell Aeronautical Lab., Buffalo, N. Y., 70N20545, Feb. 5, 1970, 23 pgs.

(3) Grodzka, P. G., "Zero-Gravity Solidification", LMSC, Huntsville, AL, Contractor No. LMSC-HREC-D148619, March, 1970, p. 27.

(4) Frost, R. T., "Techniques and Examples of Zero-G Melting and Solidification Processes", Unique Manufacturing Processes in Space Environment, NASA Publication ME-70-1, (71N26011), April, 1970, p. 12.

Abstract: The processes or improved methods of processing exploiting weightlessness: elimination of melt phase density separation and thermal convection; moldless solidification; surface tension and electromagnetic forming. General requirements for space environment facilities.

(5) Bredt, J. H., "Solidification and Crystal Growth in Space: The NASA Skylab Program", The Second National Conference on Crystal Growth, Princeton, N. J., Aug., 1972.

(6) Johnson, P. C., "Development of Techniques for Processing Metal-Metal Oxide Systems", Arthur D. Little, Inc., Contract NAS8-29145, Contractor No. Little 8-29145-MPR-1, Nov.,1972.

Section IV. A. 1.

(7) "The Solidification Under Zero Gravity Conditions of Binary Alloys Exhibiting Solid State Miscibility", Washington State University, NASA Contract NAS8-29725, Contractor No. Su8-29725-1PR-1, May 1, 1973.

(8) Miller, R. I., "Study of Liquid - Solid Transition for Materials Processing in Space", Boeing Aerospace Co., Huntsville, AL, Contract NAS8-28664, NASA-CR-124294 (73N27596), May, 1973, 47 pgs.

Abstract. Influence of magnetic fields and near zero gravity conditions on the behavior of dense liquid near the solidification point.

(9) Aubin, W. M., Larson, D., Jr., Geschwind, G. I., "Research of Metal Solidification in Zero-G State Test Apparatus and Instrumentation", Grumman, Bethpage, N. Y., NASA Contract NAS8-28604, NASA-CR-124464 (74N10527), Sept., 1973, 74 pgs.

Abstr. : Drop tower experiment of metal melting and resolidifying in three second free fall, measuring temperature-time histories of 0.05 cm Ni and 1090 steel droplets. Results of metalurgical analysis.

(10) Walter, H. V., "Evaluation of Semiconductor Specimens by X-Ray Analysis," UAH, Contract NAS8-29650, ALA.U.RI-29650-IR, Nov., 1973.

(11) "Solidification of Metals and Semiconductors", Summary Report USRA, Prepared for National Academy of Engineering 1974 Summer Study, 1974.

Abstract: Summarization of Solidification phenomena applications advantages of space processing.

(12) Yue, J. T., Voltmer, F. W., "Influence of Gravity-Free Solidification on Microsegregation, TI, Dallas, TX, Third Space Processing Symposium, M-74-5, June, 1974, pgs.375-424.

Section IV. A. 1.

(13) McKannan, E. C., "Metallurgical Processing in Space", NASA/MSFC, AIAA/AGU Conference on Scientific Experiments of Skylab, AIAA Paper 74-1239, Nov., 1974.

Abstract: Correlation of Apollo and Skylab Metallurgical experiment data.

(14) Steurer, W. H., Wood, G. B., "Low-G Experiments for Metal Membranes Final Report on the Preparation and Evaluation of Free-Fall Experiments", GD, San Diego, Cal., NASA Contract NAS8-28056, Report No. CASD-NAS-75026, Mar., 1975, 23 pgs.

Abstract: Final report on preparation of free-fall experiment devices and definition of experiment procedures.

(15) Yue, J. T., Koliwad, K., "Influence of Gravity-Free Solidification on Solute Microsegration - II", TI, Dallas Texas, Contract NAS8-28308, 22 pgs.

Abstract: Crystal quality of Ge crystals of Skylab experiment M559.

(16) Papazian, J. M., "Contained Polycrystalline Solidification in Low-G", Grumman, Bethpage, N. Y., NASA Contract NAS8-31530, March, 1976.

(17) Ahlborn, H., "Possibilities for Improving Alloys with Special Physical Properties in Space", University of Hamburg, Germany, Second European Symposium on Material Sciences in Space, Frascati, Italy, April, 1976.

Abstract: Many alloys with special physical properties (magnetic, electrical, etc.) are suited for preparation and improvement in space.

(18) Heye, W., Klemm, M., "Melting of a PbAgBaO - Powder Alloy under O-G Environment (Rocket Flight), Deformed to Wires", Zellerfeld, Germany, Second European Symposium on Material Sciences in Space, Frascati, Italy, April, 1976.

2. EXPERIMENTATION

(1) Wechsler, A. E., Berkowitz - Mattuck, J., Johnson, P. C., Griffiths, L. B., "Sphere Forming and Composite Casting in Zero-G", Aurhur D. Little, Inc., NASA-CR-61317, Jan., 1970.

(2) "Apollo Experiment Definition Study", TRW Systems Group, Downey, Cal., NASA Contract NAS8-27085, Contractor No. TRW 18677-6008-R0-00, Nov , 1971.

(3) Masubuchi, K., Muraki, T., "Phase A of Thermal Analysis of M551 and M554 Experiments for Materials Processing in Space", MIT, Cambridge, Mass., NASA Contract NAS8-28732, Contractor No. MIT 8-28732-FR-PhA, July 23, 1972.

(4) Brown, J. L. Johnson, J. W., "M553 Sphere Forming and M554 Composite Casting Experiments", Contract NAS8-28735, Contractor No. GIT/ESS A-1428, July 31, 1972.

(5) Kattamis, T. Z., "Investigation of Solidification in Zero-Gravity Environment: M553 Sphere Forming Experiment and M554 Composite Casting Experiment", NASA Contract NAS8-28734, (73N70935), Aug. 10, 1972.

(6) Pattee, H. E., Rothman, R. L., "Materials Processing in Space M512 - Phase A", Contract NAS8-28725, Contractor No. BMI 8-28725 - Ph A Aug. 72, August 15, 1972.

(7) Masubuchi, K., Muraki, T., "Phase B of Thermal Analysis of M551 Experiment for Materials Processing in Space", MIT, Cambridge, Mass., Contract NAS8-28732, Contractor MIT 8-28732-IR-1, Jan., 1973.

(8) Larson, D., Jr., Busch, G., "Investigation of KC-135 Flight Samples Solidified in Near-Zero Gravity", Grumman, Bethpage, N. Y.; NASA-CR-124179 (73N20610), Jan. 1973, 36 pgs.

Abstract: KC-135 tests of M553 Skylab hardware and analysis of Star-J Satellite (cobalt base alloy) samples by optical microscopy, scanning electron microscopy, electron microprobe, X-ray diffraction differential scanning calorimetry and microhardness.

Section IV. A. 2.

(9) Spearman, J. W., Muraki, T., "Phase B of Thermal Analysis of M552 Experiment for Materials Processing in Space", NASA Contract NAS8-28732, Contractor MIT 8-28732-IR-2, Jan., 1973.

(10) Johnson, P. C., Peters, E. T., "M553 Research Study on Materials Processing in Space", Arthur D. Little, Contract NAS8-28723, Contractor No. LITTLE 74671.

(11) Hubbard, J. L. Johnson, J. W., "Characterization of Five Spheres Formed During Ground Test of the M553 Experiment at MSFC", Georgia Institute of Technology, Atlanta, GA, Contract NAS8-28735, Contractor No. GIT/EES A-1428-1, Phase B, 1973.

(12) Pattee, H. E., Monroe, R. E., "Materials Processing in Space M512 Skylab M551 Samples - Skylab M552 Samples - Study Report", Battelle Memorial Institute, Contract NAS8-28725, BMI-8-28725-SR, Phase B, July, 1973.

(13) Larson, D. J., Jr., "Investigation of Ground Based Simulation Skylab Samples - Final Report on Phase B", Grumman, Contract NAS8-28728, Grumman RM-576, Phase B, Aug. 1973.

Abstract: Ground based simulation Skylab samples.

(14) Aubin, W., Larson, D. J., Geschwind, G., "Sphere Forming in Zero-G", 7th AIAA Space Simulation Conference, Los Angeles, Nov., 1973.

(15)Brashears, M. R., Robertson, S. J., "Research Study on Materials Processing in Space Experiment M512 - Final Report", LMSC, Huntsville, AL, NASA-CR-120185 (74N21068), Dec. 1973, 140 pgs.

Abstract: Study of gravity effect on fluid mechanics of certain molten metal processes. Analyses of M551 metals Melting Experiment and M553 Sphere Forming Experiment. Comparison with ground based and KC-135 experimental results.

Section IV. A. 2.

(16) Kattamis, T. Z., "Investigation of Solidification in Zero-Gravity Environment: M553, Evaluation of Skylab Specimens", Contract NAS8-28734 (74N20126), Dec. 4, 1973, 43 pgs.

Abstract: Evaluation of specimens SL-1.6, SL-2.8, SL-2.4, SL-1.10, and SL-1.11; comparison with ground processed specimens; sphericity, density, microporosity.

(17) Monroe, R. E., "Characterization of Metals Melting Disco Skylab Experiment M551-Final Report", Battelle Memorial Institute, Contract NAS8-28725, BMI-8-28725-FR, Dec. 4, 1973.

(18) Hubbard, J. L., Johnson, J. W., "Characterization of Four Spheres Processed as Part of the M553 Sphere Forming Experiment Performed During the Skylab 1/2 Flight", Georgia Institute of Technology, Atlanta, GA, Contract NAS8-28735, GIT/EES A-1428-1, Dec., 1973.

(19) Monroe, R. E., Pattee, H. E., "Characterization of Exothermic Brazing Components Skylab Experiment M552 - Final Report", NASA Contract NAS8-28725, BMI-8-28725-FR, Dec., 1973.

(20) Tobin, J. M, Kossowsky, R., "Final Report on M551, M552, and M553", Westinghouse, Pittsburgh, NASA Contract NAS8-28730, WANL-954-Rev., Dec, 1973.

(21) Larson, D. J., Jr., Li, C., "Specimen Analysis of the Skylab M553 Metals Melting and Solidification Experiment", Grumman, Bethpage, N. Y., Contract NAS8-28728, Feb. 1974.

Abstract: Specimen Analysis of Skylab M553 Metals.

(22) Larson, D. J., Jr. "Skylab M553 Sphere Forming Experiment", Grumman, Bethpage, N. Y., Third Space Processing Symposium, M-74-5, Vol. I, June, 1974, pgs. 101 -115.

Abstract: Preliminary Results of M553 Sphere Forming Experiment.

Section IV. A. 2.

(23) Lundquist, C. A., "Skylab Experiments on Metals", NASA/MSFC/SSL, ESRO Space Processing Symposium, Frascati, Italy, March, 1974.

Abstract: Review of the eight Skylab experiments dealing with metal processing in space.

(24) Williams, J. R., "M552 Exothermic Brazing", NASA/MSFC, Third Space Processing Symposium, M-74-5, Vol. I, June, 1974, pgs. 33-85.

Abstract: M552 - Brazing in Space using an exothermic technique. Presentation of preliminary results.

(25) Deruyttere, A., Aernaudt, E., "M565 Silver Grids Melted in Space", Catholic University, Lieven, Belgium, Third Space Processing Symposium, Vol, I, M-74-5, May, 1974, pgs. 159-203.

Abstract: Preliminary results of study of the behavior of porous material when melted and resolidified in space.

(26) Larson, D. J., Jr., "Specimen Analysis of Skylab M553 Experiment Flight Samples", Grumman, Bethpage, N. Y., Contract NAS8-28728, Contract Report No. RE-486, August, 1974, 74 pgs.

Abstract: Metallurgical analyses of six Skylab M553 samples to study containerless solidification and the effects of weightlessness on solidification processes.

(27) Larson, D. J., Jr., Busch, G., "Investigation of KC-135 Flight Samples Solidified in Near-Zero Gravity", Grumman Bethpage, N. Y., NASA-CR-138168 (74X73561), Jan. 1, 1975.

(28) Ang, Choh-Yi, Lacy, L. L., "Monotectic and Syntectic Alloys: ASTP Experiment MA-044", NASA/MSFC/SSL, Postflight Preliminary Technical Report, NASA-TMX-64956, Sept.,1975, 45 pgs.

Section IV.A.2.

(29) Larson, D. J. Jr., "Preliminary Science Report of the ASTP Experiment MA-070", Grumman, Bethpage, N. Y., Oct. 1975.

Abstract: Study of Solidification of magnetic materials.

(30) Uhlmann, D. R., "Technical Report on Experiment 74-36/15 Flown on SPAR I", MIT, Cambridge, Mass., NASA Contract NAS8-31350, Feb., 1976.

Abstract: Study of Solidification Interface.

(31) Heye, W., Klemm, M., "Herstellung eines Supraleitiers 2. Art nach dem (in Sitw) Verfahren auf Schemlzmetallurgischen Wege," SPAR I Rocket Experiment 74-63 Report, Abt. Werkstoffprufung des Instituts fur Metallkunde/und Metallpnysik der Technischen Universtrat Clausthal, April, 1976.

Abstract: Study of superconducting properties.

(32) Johnston, M. H., Griner, C. S., "The Direct Observation of Solidification as a Function of Gravity Levels," NASA/ MSFC, SPAR I Experiment 74-21, April, 1976.

(33) Passaglia, E., "The Metallurgy Experiments on ASTP", National Bureau of Standards, Washington, D. C., Second European Symposium on Material Sciences in Space, Frascati, Italy, April, 1976.

Abstract: Review of four metallurgical studies on ASTP.

(34) Patten, J. W., Greenwell, E. N., "Feasibility of Producing Closed-Cell Metal Forms in a Zero-G Environment from Sputter Deposited Inert Gas Bearing Metals and Alloys", Battelle-Northwest, Richland, Washington, NAS8-31384, April, 1976.

Abstract: Preliminary Report of SPAR I Experiment 74-10.

(35) Ang, C. Y. and Lacy, L. L., "Low-Gravity Homogenization and Solidification of Aluminum Antimonide," Symposium on Material Science in Space at the 19th Meeting of COSPAR, Philadelphia, PA, June 1976, Paper D.2.1.

Section IV. A. 3.

3. STUDIES OF SOLIDIFICATION PHENOMENA

(1) Bannister, T. C., "Studies of Zero-Gravity Effects on Solidification", NASA/MSFC/SSL, (71N11725), Oct., 1969.

Abstract: Major activities initiated in support of space manufacturing, aimed primarily at defining the role of gravity in solidification processes.

(2) Grodzka, P. G., "Space Environmental Effects on Solidification Study - Zero Gravity Solidification", LMSC, Huntsville, AL, NASA-CR-102696 (70N36665), Mar., 1970, 57 pgs.

Abstract: Theoretical analysis of zero gravity effects on solidification. Fine single crystal candidates for space manufacturing: silicon, germanium, KTN, BANANAS (barium, sodium niobate), and CuCl.

(3) Fabiniak, T. J., "Investigation of Zero Gravity Effects on Material Properties", Cornell Aeronautical Laboratory, Final Report, NASA-CR-102874 (70N42189), April, 1970, 61 pgs.

Abstract: Combinations of Al, Ag, Zn, and Sn with carbon or boron-carbide powers subjected to liquid phase sintering in vacuum to determine effects of dissimilar densities and surface tensions. Wetting, absorption, and defect migration.

(4) Mukherjee, J. L., Gupta, K. P.,Li, C., "Purification Kinetics of Beryllium During Vacuum Induction Melting", State University of N. Y., Grumman Aerospace, NASA-CR-123946 (N73-13512), Oct. 1972, 22 pgs.

Abstract: Quantitative treatment of binary alloy evaporation kinetics.

(5) Mukherjee, J. L., Gupta, K. P., Li, C., "Evaporation Segregation in 80% Ni - 20% Cr and 60% Fe 40% Ni Alloys", State University of New York, Grumman Aerospace, NASA-CR-123993 (N73-14562), Oct., 1972, 15 pgs.

Section IV. A. 3.

(6) Greisenauer, N. M., "Undercooling of Materials During Solidification in Space", Battelle Memorial Institute, Contract NAS8-28749, Contractor No. BMIT 8-28749-ISR-1, Oct. 1972.

(7) Li, C. H., "Evaporative Solidification", Grumman, Bethpage, N. Y., Second Symposium of the American Association of Crystal Growth, Princeton University, N. J., July, 1972.

(8) Li, C. H., "Normal Freezing of Ideal Ternary Systems of the Pseudobinary Type", Grumman, NASA-CR-129934 (N73-14563), Nov., 1972, 21 pgs.

Abstract: The equation of normal freezing for ideal ternary liquid solutions solidified into ideal solid solutions of the pseudobinary type is given. Sample calculations for the GA-Al-As system are given.

(9) Li, C. H., "Normal Evaporation of Binary Alloys", Grumman, NASA-CR-124040 (N73-16558), Nov., 1972, 29 pgs.

Abstract: The differential equation of normal evaporation is solved for special cases, applied to a Ni-Al alloy and several binary iron alloys. Accuracy of prediction is checked against experimental data Fe-Ni, Ni-Cr, and vacuum purification of benzllium.

(10) Li, C. H., "Segregation Effects During Solidification in Weightless Melts", Grumman, NASA-CR-124358 (N73-30510), June, 1973, 350 pgs.

Abstract: Study of evaporative melt segregation and freezing segregation, development of normal evaporation equations, and correlation with experimental data reported in the literature.

(11) Yates, I. C., and Yost, V. H., "Research Rocket Tests RR-1 (Black Brant VC) and RR (Aerobee 170A): Investigation of the Stability of Bubbles in Plain and Fiber-Reinforced Metal Melted and Solidified in a Near-Zero-g Environment", NASA TM X-64665, Oct., 1972.

Section IV. A. 3.

(12) McNutt, R. C., "Solidification Kinetics", Athens College, Athens, AL, NASA Contract NAS8-30561, Sept., 1973.

(13) Li, C. H., "Evaporation in Space Manufacturing", Grumman, AIAA/ASME 1974 Thermophysics and Heat Transfer Conference, Boston, Mass., July, 1974, 14 pgs.

Abstract: Evaporation equations for predicting the compositional changes with time and temperature have been developed and correlated with actual experimental data.

(14) Haessner, F., Hemminger, W., Lukas, H. L., "Solution Calorimetry in Zero Gravity for the Determination of Enthalpies of Formation of Reactive Metals", Technical University of Braunschweig, Braunschweig, Germany, AIAA/ASME 1974 Thermophysics and Heat Transfer Conference, Boston, Mass., AIAA Paper 74-666, July, 1974, 4 pgs.

(15) Papazian, J. M., Wilcox, W. R., "Thermal Migration of Bubbles and Their Interaction with Solidification Interface", Grumman Aerospace, Bethpage, N. Y., SPAR I Experiment 74-36, NASA Contract NAS8-31529, Contractor No. RM-616, April, 1976.

(16) Elwell, D., "Measurement of Properties of High Temperature Solutions", Portsmouth Polytechnic, United Kingdom, Second European Symposium on Material Sciences in Space, Frascati, Italy, April, 1976.

Abstract: Design of apparatus and choice of optimum conditions for the growth of crystals in bulk or as expitaxial films requires a knowledge of a range of properties of solutions.

(17) Fredriksson, H., "Possible Dendritic Growth and Segregation Phenomena During Solidification of Alloys in Space", The Royal Institute of Technology, Stockholm, Sweden, Second European Symposium on Material Sciences in Space, Frascati, Italy, April, 1976.

Section IV. A. 3.

Abstract: Influence of zero gravity on the concentration and temperature distribution around a growing dendrite in a binary alloy.

B. IMMISCIBLES

(1) Hammel, R. L., Kirkpatrick, M. E., Reger, J. L., "Reduced Gravity Processing of Homogenized Immiscible Metal Alloys," TRW, Redondo Beach, Cal., Space Processing and Manufacturing, MF-69-1 (70N14660), Oct., 1969, pgs. 183-184.

Abstract: The effects of low gravity on immiscibility limits of two phase liquid melts, base solidification processes. Experiment performance limitations, requirements, interface criteria.

(2) Reger, J. L., "Experiment Development of Processes to Produce Homogenized Alloys of Immiscible Metals - Phase III", TRW, Redondo Beach, Cal. NASA Contract NAS8-27085, TRW-18677-6018-R0-00, Sept. 1972.

(3) Reger, J. L., "Low Gravity Processing of Immiscible Materials", TRW, 23rd IAF International Astronautical Congress, Vienna, Austria, 72A45155, Oct., 1972, 9 pgs.

Abstract: Procedures and results of Apollo 14 composite casting demonstration, MSFC drop tower tests, and KC-135/M512 Facility tests.

(4) Reger, J. L., "Study on Processing Immiscible Materials in Zero Gravity - Interim Report", TRW, NASA Contracts NAS8-28267, 8-27085, 8-28309, May, 1973.

(5) "Investigation of Immiscible Systems and Potential Applications", Battelle Memorial Institute, Contract NAS8-29748, BMI8-29748, MPR-1, July 9, 1973.

(6) Reger, J. L., Yates, I. C., Jr., "Preparation and Metallurgical Properties of Low Gravity Processed Immiscible Materials", TRW, NASA/MSFC, 12th Annual AIAA Aerospace Sciences Meeting, Washington, D. C., AIAA Paper 74-207 (74A18826), Jan., 1974, 11 pgs.

Section IV. B.

Abstract: Seven metallic systems processed in low gravity tests: drop tower at Marshall Space Flight Center, M-512 aboard KC-135 aircraft and the M518 aboard Skylab exhibit more uniform dispersion and microstructure than the gravity samples.

(7) Lacy. L. L., Otto, G. H., "The Electrical Properties of Zero-Gravity Processed Immiscibles", NASA/MSFC, UAH, 12th Annual AIAA Aerospace Sciences Meeting, Washington, D. C., AIAA Paper 74-208 (74A18853), Feb.1, 1974, 6 pgs.

Abstract: Electrical properties of zero gravity processed Ga-Bi samples differ significantly from properties of individual components and ground control samples, and possibly form a new class of electronic material.

(8) Lacy, L. L., Otto, G. H., "Quick Look Report on Skylab IV Science Demonstration (TV102), Immiscible Liquids", NASA/MSFC, UAH, March 15, 1974.

(9) Otto, G. H., "Immiscible Alloys - Ground Based Studies", UAH, Contract NAS8-27809, June, 1974, 53 pgs; CR 120796.

(10) Reger, J. L., "M557 Immiscible Alloy Compositions", TRW, Redondo Beach, Cal., Third Space Processing Symposium: Skylab Results, M-74-5, Vol. I, June, 1974, pgs. 133-159.

Abstract: Preliminary results of M557 data analysis.

(11) Gelles, S. H., "Immiscible Materials and Alloys", Battelle, Columbus, Ohio, Third Space Processing Symposium: Skylab Results, M-74-5, Vol. II, June, 1974, pgs. 1003-1031.

Abstract: Review of past activities in immiscible systems studies, current research at Battelle, and explore potentially useful immiscible systems which might benefit from 0-g processing.

Section IV. B.

(12) Lacy, L. L., Otto, G. H., "The Behavior of Immiscible Liquids in Space", NASA/MSFC, UAH, AIAA/ASME 1974 Thermophysics and Heat Transfer Conference, Boston, Mass., AIAA Paper 74-668, July, 1974, 5 pgs.

Abstract: Report on TV102 Skylab results.

(13) Lacy, L. L., Otto, G. H., "The Stability of Liquid Dispersions in Low Gravity", NASA/MSFC, UAH, AIAA/AGU Conference on Scientific Experiments of Skylab, Huntsville, AL AIAA Paper 74-1242, Nov. 1, 1974.

(14) Johnson, A. A., Anatatmuka, R. P., Horylev, R. J., Gupta, S.P., "The Solidification Under Zero-Gravity Conditions of Binary Alloys Exhibiting Solid State Immiscibility", Washington State Univeristy, Pullman, Wash., NASA Contract NAS8-29725 - Interim Report, Nov. 1, 1974, 61 pgs.

Abstract: Development of new materials manufacturing processes for space processing in the area of binary alloys which exhibit solid state immiscibility. The initial material system studied was gold-silicon.

(15) Markworth, A. J., Oldfield, W., Duga, J., Gelles, S. H., "Investigation of Immiscible Systems and Potential Applications", Battelle Memorial Institute, Columbus, Ohio, NASA Contract NAS8-29748, Final Report, April, 1975, 111 pgs.

Abstract: Potential applications for systems with liquid phase miscibility gaps were explored. Possibilities included superconductiors, electrical contact materials, superplastics, catalysts, magnetic materials. The role of space processing in their production was also analyzed.

(16) Gelles, S. H., Markworth, A. J., Watts, C. R., "Rocket Experiment 74-30: Agglomeration in Immiscible Liquids at Low-Gravity", Battelle Institute, Columbus, Ohio, Dec. 31, 1975.

Section IV. B.

(17) Desforges, C. D., "Immiscible Alloy Experiments in Space", Buckinghamshire, United Kingdom, Second European Symposium on Material Sciences in Space, Frascati, Italy, April, 1976.

Abstract: Review of available experimental data on immiscible alloy solidification experiments which have been carried out in terrestrial and space environments.

(18) Lacy, L. L. and Otto, G. H., "Electrical Resistivity of Gallium-Bismuth Solidified in Free Fall," AIAA Journal, Vol 13, February 1975, pp 219-220.

(19) Otto, G. H., "Studies on Immiscible Alloys - 2nd Semi-Annual Report, NASA CR # 120643, October 1974, NAS8-27809.

(20) Otto, G. H., "Studies on Immiscible Alloys - 3rd Semi-Annual Report," NASA CR 129764, March 1975, NAS8-27809.

(21) Otto, G. H., "Studies on Immiscible Alloys - Final Report," NASA CR 144296, January 1976, NAS8-27809.

C. COMPOSITES/EUTECTICS

(1) Ranch, H. W., Sr., et. al., Composite Fiber and Fibrous Composit Material, Academic Press, 1968.

(2) Sicka, R., Rose, S., Harkvlich, T., "Whisker Reinforced Composite Materials", Horizons Research, Inc., Cleveland, Ohio, AD-760562 (73N73763), Aug. 11, 1967, 56 pgs.

Abstract: Investigation of electrophoretic deposition with whisker alignment. Secondary reinforcement of boron-epoxy system, copper-alumina whisker composites, and silicon carbide or alumina whisker reinforced epoxy composites.

(3) Fleck, J. N., Jablonowski, E. J., "New World of Composites - What We Can Expect in the 1970's," Metal Progress, Vol. 95, March 1969, pgs. 99-103.

(4) Kirkpatrick, M. E., Reger, J. L., Staudhammer, K. P., Toy, A., "A Continuous Process for the Production of Whisker Reinforced Composites", TRW, Journal of Composite Materials, Vol. 3, (69A28676), April 1969.

(5) Steurer, W. H., "Composite Casting Superior Structural Materials Through the Combined Application of Unique Zero-G Effects", GD, San Diego, Cal., (70N44672), Oct. 21, 1969, 24 pgs.

Abstract: Proposes specific casting experiments and assesses modifications to basic process.

(6) Wechsler, A. E., Berkowitz-Mattuck, J., Johnson, P. C., Griffiths, L. B., "Spherical Forming and Composite Casting in Zero-G", Arthur D. Little, Cambridge, Mass.,NASA Contract NAS8-21402, (70N20532), Feb. 5, 1970, 26 pgs.

Abstract: Description of program for identification and selection of materials and methods for spherical forming and composite casting experiments of the AAP Workshop.

Section IV. C.

(7) "Sphere Forming and Composite Casting in Zero-G", Arthur D. Little, Cambridge, Mass., NASA-CR-61317 (70N21873), Jan., 1970, 128 pgs.

Abstract: Guidelines for hardware weight, volume, power, sample heating and solidification methods, etc. Candidate materials screening and selection was verified by ground based experiment. Engineering drawings included.

(8) Steurer, W. H., "Composite Casting Superior Structural Materials through the Combined Application of Zero G Effects", GD, San Diego, Cal., (70N20538), Feb. 5, 1970, 24 pgs.

Abstract: Experimental program is proposed, specifying: materials, batch size, and mold shape; design, vehicle arrangement, and support requirements; controls, astronaut assistance and expected results.

(9) "Research Study on Composite Castings", Arthur D. Little, Cambridge, Mass., Contract NAS8-25709, LITTLE 8-25709-MPR-Jun 1970, June 17, 1970.

(10) Yue, A. S., "Directional Solidification of Eutectic Composites in Space Environment", UCLA, Los Angeles, Cal., Contract NAS8-26402, Cal. U. 8-26402-QR-Jan. 71, January 25, 1971.

(11) "Refactory Composites", UAH, Huntsville, AL, Contract NAS8-26991, Ala. U. RI-8-26991-MPR, April 30, 1971.

(12) "Research Study on Composite Castings", Arthur D. Little, Cambridge, Mass., Contract NAS8-25709, May 26, 1971.

(13) Yates, I. C., Jr., "Report on Results of Apollo 14 Composite Casting Demonstration", NASA/MSFC, MSFC Memo S&E-PT-IN-71-1, July 13, 1971.

Section IV. C.

(14) Cook, J. L. Lambdin, F., "Fabrication of Carbon-Carbon Composites Using Electrostatic Fiber Deposition (Flocking)", Union Carbide, Oak Ridge, Tenn., SAMPE Quarterly, Vol. 2, (71A40140), July, 1971, 10 pgs.

Abstract: Densification using coal tar pitch impregnation-carbonization cycles. Isotropy control by fiber orientation.

(15) "Apollo 14 Composite Casting Demonstration Final Report", Arthur D. Little, Cambridge, Mass., NASA-CR-61369, Aug.20, 1971.

(16) Steurer, W. H., Kaye, S., "Preparation and Evaluation of Apollo 14 Composite Experiments", GD, San Diego, Cal., GDCA Report DBG-71-009, Contract NAS8-24979, Aug, 1971.

(17) Fabiniak, R. C., Fabiniak, T. J., "Test and Evaluation of Apollo 14 Composite Casting Demonstration Specimens and Flight and Control Samples", Cornell Aeronautical Lab., Contract NAS8-27106, NASA-CR-61366 (72N16331), Sept., 1971, 195 pgs.

Abstract: Results of liquid phase sintering (experiments 1 and 2) and dispersion of dense particles on a metal matrix rising shaking modes or forces in the system. Qualitative and quantitative interpretation of results.

(18) Reger, J. [illegible], "Test and Evaluation of Apollo 14 Composite Casting Demonstration Specimens 6, 9, and 12, Phase 1," TRW, Redondo Beach, Cal., Contract NAS8-27085, NASA-CR-61367 (N72-15542), Sept., 1971, 90 pgs.

Abstract: Evaluation of dispersion for mixtures of paraffin and sodium acetate; paraffin, sodium acetate and argon; and paraffin, sodium acetate, and 100 micrometer diameter tungsten spheres. Photographic and microstructure examinations, ensity, droplet size and distribution were measured.

Section IV. C.

(19) Yates, T. C., Jr., "Apollo 14 Composite Casting Demonstration", NASA/MSFC, NASA-TM-X-64641 (72N23498), Oct., 1971, 78 pgs.

Abstract: Final Report. Dispersions of particles, fibers, and gases in liquid metal matrices were maintained during translunar and transearth melting and solidification. Evaluation was made by comparison with ground-processed control samples.

(20) Pardusky, J. A., "Preparation of Plain and Fiber-Reinforced Metal Foam Specimen for Rocket Flight Experiments", GS/Convair, San Diego, Cal., Convair Report CASD-ERR-73-003, May, 1972.

(21) Douglas, F. C., "Research Study on Materials Processing in Space M554 Experiment", Contract NAS8-28724, UAC8-28724-Mv-1, June 30, 1972.

(22) Brown, J. L., Johnson, J. W., "M553 Sphere Forming and M554 Composite Casting Experiments, Summary Report, Phase A", Georgia Institute of Technology, Contract NAS8-28735, GIT/EES A-1428, July 31, 1972.

(23) "Metallurgical Evaluation of Wire Reinforced Refractory Composites for Space Shuttle Reuse", UAH, Huntsville, AL, Contract NAS8-26991, UARI RR-125, Aug., 1972.

(24) George, F. D., "Preparation of Single Grain Eutectics for the M566 Experiment", UAC, Pratt and Whitney, Contract NAS8-28724, UAC L911515-1, Dec. 15, 1972.

(25) Steurer, W. H., Kaye, S., "Preparation of Composite Materials in Space", GS, San Diego, Cal., Contract NAS8-27806, NASA-CR-124172 (73N20609), Jan., 1973, 192 pgs.

Abstract: A program of sub-orbital and orbital experiments for 1972-1978 to identify materials, processes and experimental equipment for metal-base fiber and particle composites, controlled density metal foams, and eutectic alloys.

Section IV. C.

(26) Grodzka, P. G., Bourgeois, S. V., "Fluid and Particle Dynamic Effects in Low-G Composite Casting", LMSC, Huntsville, AL NASA-CR-124216 (73X10283), Jan., 1973, 46 pgs.

Abstract: Reexamination of Apollo 14 composite casting to explain unusual results: phase change and surface tension convection, Marangoni flow bubble and droplet migration.

(27) "Directionally Solidified Composites: Known Also as In Situ Composites or Directionally Solidified Eutectics", NMAB ad hoc Committee on Directional Solidification, Final Report NMAB-301, April, 1973.

(28) "Space Processing of Composite Materials", GS, San Diego, Contract NAS8-29620, GD/C 8029620-PR-1, April 30, 1973.

(29) "Processing Eutectics in Space", UAC, Pratt and Whitney, Contract NAS8-29669, PWA 8-29669 MPR, June 30, 1973.

(30) Gelles, S. H., "Process Development for Producing Fine Grain Castings in Space", Battelle Memorial Institute, Columbus, Ohio, Contract NAS8-29626, BMI-8-29626-MPR-1, July, 1973.

(31) "Directional Solidification of Eutectic Composites in Space", UCLA, Contract NAS8-29854, Cal. U. 8-29854-Sept. 73, Sept. 30, 1973.

(32) Kawada, T., "30-Day Report on the Evaluation of SL3 Samples of Skylab Experiment M-561", National Research Institute for Metals, Tokyo, Japan, Nov., 1973, 11 pgs.

(33) Hubbard, J. L., Johnson, J. W., "Characterization of Ground Base Specimen No. A72-926B Processed as a Part of the M566 Composite Casting Experiment", Contract NAS8-28735 GIT/EES A-1428-2, Phase B, Feb., 1974.

Section IV. C.

(34) Takahashi, S., Kawadsa, T., "Preparation of Silicon Carbide Whisker Reinforced Silver Composite Material in a Weightless Environment - Skylab Experiment M561", National Research Institute for Metals, Tokyo, Japan, Third Space Processing Symposium, Vol. I, M-74-5, June, 1974, pgs. 203-235.

Abstract: Preliminary Results of Skylab Experiment M561.

(35) Hasemeyer, E. A., Lovoy, C. V., Lacy, L. L., "Skylab Experiment M566 Copper-Aluminum Eutectic", NASA/MSFC, Third Space Processing Symposium, Vol. I., M-74-5, June, 1974, pgs. 457-469.

Abstract: Preliminary science results of Skylab experiment M566.

(36) Yue, A. S., "M564 Metal and Halide Eutectics", UCLA, Third Space Processing Symposium, Vol. I, M-74-5, June, 1974, pgs. 469-491.

Abstract: Preliminary science results of Skylab experiment M564.

(37) Douglas, F. C., Galasso, F. S., "Eutectic Solidification", UAC, Hartford, Conn., Third Space Processing Symposium, Vol. II, M-74-5, June, 1974, pgs. 939-953.

Abstract: Discussion of techniques of solidification. Combination of experimental and analytical thermal studies for optimization of the solidification process.

(38) Bhat, B. N., "Concentration Changes During Eutectic Solidification", NASA/MSFC, Third Space Processing Symposium, Vol. II, M-74-5, June, 1974, pgs. 953-960.

Abstract: Suggest process to minimize concentration changes.

Section IV. C.

(39) Yue, A. S., Yue, B. K., Lee, J. Y. M., "Holide Eutecti Growth in Apollo-Soyuz Test Project", UCLA, October, 1975.

Abstract: Preliminary science results of ASTP experiment MA-131.

(40) Stuerer, W. H., Kaye, S., "Space Processing of Composite Materials", GD, San Diego, Cal., Contract NAS8-29620, Final Report, Contractor No. CASD-NAS-75-025, Feb., 1975, 96 pgs.

Abstract: Study objective was definition of materials and processes for the testing of aluminum base fiber and particle composites, and metal foams under extended low-g conditions, in particular for the SPAR program.

(41) Pond, R. B., "Post Flight Technical Report of SPAR I Rocket Experiment 74-5 - Space Solidification of Pb-Sb Eutectic", Marvaland, Inc., Westminster, MD, NASA Contract NAS8-31534, March, 1976.

(42) Raymond, L., Ang, C. Y., "Casting Dispersion Strengthened Composites at Zero Gravity", SPAR I Rocket Experiment 74-34, NASA Contract NAS8-31539, March, 1976.

(43) Berghezan, A., "Fabrication of Composite Materials in Space", Universite' Catholique de Louvain, Belgium, Second European Symposium on Material Sciences in Space, Frascati, Italy, April, 1976.

(44) Gondi, P., "Dispersion Hardened Alloy Experiments", Universita di Bologna, Italy, Second European Symposium on Material Sciences in Space, Frascati, Italy, April, 1976.

Abstract: Suggested improvements to alloy experiments in space.

(45) Lohberg, K., "Results of Studies on Wetting Behavior", Technische Universitat Berlin, Berlin, Germany, Second European Symposium on Material Sciences in Space, Frascati, Italy, April, 1976.

Section IV.C.

(46) Lacy, L. L. "Preliminary Report on the Physical Properties of Al-Cu Eutectic Samples Processed on Skylab 4," NASA/MSFC Report Misc-SSL-74-2, April, 1974, 15 pages.

D. CRYSTAL GROWTH

1. GENERAL

(1) Utech, H. P., Flemings, M. C., "Thermal Convection in Metal-Crystal Growth: Effect of a Magnetic Field", Proceedings of 1st International Conference on Crystal Growth, (published as Supplement to Physical Chemical Solids, H. S. Peiser, editor, 1967, pg. 651).

(2) Schlicta , P. G., Knox, R. E., "Growth of Crystals by Centrifugation", Proceedings of the 2nd International Conference on Crystal Growth, Birmingham, U. K., published in Journal of Crystal Growth, Vol. 3/4, 1968, pg. 808.

(3) Grodzka, P. G., "Gravity-Driven and Surface Tension-Driven Convection in Single Crystal Growth", LMSC, Huntsville, AL, (71N11728), Oct., 1969, 14 pgs.

Abstract: Analytical and mathematical studies of floating zone and Czochralski single crystal growth techniques to determine the role of convection.

(4) Roy, U., "Investigation of Crystal Growth", UAH, Huntsville, AL, NASA-CR-122553, 72X10284, Jan., 1970.

(5) Mazelsky, R., "Zero Gravity Crystal Growth," Westinghouse, Pittsburgh, PA, (70N20533), Feb. 5, 1970, 9 pgs.

Abstract: Principles and techniques of crystal growth. Outline of projected solution growth experiments.

(6) Henry, E. C., McCreight, L. R., "Space Processing of Electronic Crystals", GE, Valley Forge, PA, (70N20520), Feb. 5, 1970, 20 pgs.

Abstract: Glass solvent method of growing high temperature oxidic crystals Zero gravity processing should reduce convection produced vacancies and dislocations as well as prevent rapid settling of the solutes.

Section IV. D. 1.

(7) Griffin, R. N., Henry, E. C., McCreight, L. R., Rubin, B. A., "Investigation of the Preparation of Materials in Space", GE, Valley Forge, PA, NASA Contract NAS8-24683, Final Report, NASA-CR-102749 (70N31862), Mar., 1970, 90 pgs.

Abstract: Emphasizing electronic crystals grown from solution, and developing a solution type process to demonstrate the growth of potassium solium niobate crystals from potassium sodium silicate glass solution.

(8) Duncan, C. S., Mazelsky, R., Rubenstein, M., "Zero Gravity Crystal Growth," Westinghouse, Pittsburgh, PA, NASA Contract NAS8-24509, NASA-CR-102731 (70N30092), April 29, 1970, 90 pgs.

Abstract: Operational unit for growing crystals in zero gravity, specifically gallium arsenide.

(9) Johnston, M. H., "Preliminary Terrestrial Based Experiments on Gravity - Affected Crystal Growth", NASA/MSFC, NASA-TM-X-53999 (72N25693), March 13, 1970, 19 pgs.

Abstract: Tin melted in a furnace on a centrifuge was cooled during rotation to grow single crystals. Visual analyses were made with a scanning electron microscope.

(10) Jain, V. K., "Utilization of Space Environment for Preparing Highly Perfect Crystals", NASA/MSFC, NASA-TM-X-64564 (71X78072), Dec. 11, 1970, 39 pgs.

(11) Kroes, R. L. Davis, J. H., "Investigation of Crystal Growth in Zero Gravity Environment", NASA/UAH, Contract NAS8-24612, 74K10306, June, 1972.

(12) Ulrich, D. R., Chung, A. M., Yan, C. S., McCreight, L. R., "Economic Analysis of Grystal Growth in Space", GE, Valley Forge, PA, NASA-CR-12395 (N73-12806), July, 1972, 178 pgs.

Section IV. D. 1.

Abstract: Space Processing of sophisticated compound single crystals for electronics in 1980's (ceramic oxides and compound semi-conductors) with maximum perfection, purity, and size is suggested.

(13) Chu, T. L., "Physical Phenomena Related to Crystal Growth in the Space Environment", SMU, Dallas, TX, NASA/LRC Contract NAS1-11869, Final Report, Nov., 1972, 30 pgs.

Abstract: Study of crystal growth mechanisms which may be affected by the space environment, technical and scientific advantages without regard to economic advantage, recommendations of several Shuttle experiments.

(14) Davis, J. H., Lal, R. B., Walter, H. U., Castle, J. G., Jr., "Investigation of Crystal Growth in Zero Gravity Environment and Investigation of Metallic Whiskers", UAH, Huntsville, AL, NASA-CR-124065 (73N17778), Dec., 1972, 255 pgs.

Abstract: Theoretical and experimental work on near-zero gravity effects on crystal and metallic whisker growth during Skylab and Apollo experiments. Indium-bismuth compounds, bismuth single crystals, gallium arsenide films and single crystals and cadmium whiskers.

(15) Padovani, F. A., Voltmer, F. W., "Growth of a Single Crystal Ribbon in Space", TI, Dallas, TX, NASA Contract NAS8-27807, NASA-CR-124439 (73N32588), May, 1973, 45 pgs.

Abstract: Design of a ribbon puller. Attempt to grow a conventional float zone crystal in an external static magnetic field.

(16) Ulrich, D. R., Noone, M. J., Spear, K. E., White, W. B., Henry, E. C., "Crystal Growth in Fused Solvent Systems", GE, Valley Forge, PA, NASA-CR-124443 (73N32587), June, 1973, 178 pgs.

Section IV. D. 1.

Abstract: Growth of electronic ceramic single crystals from solutions including fused or glass solvents and aqueous solutions, growth and characterization of triglycine sulphate.

(17) Chu, T. L., "Physical Phenomena Related to Crystal Growth in the Space Environment", NASA-CR-2281, July, 1973.

(18) Bredt, J. H., "Report on the 1974 Gordon Research Conference on Crystal Growth and the NSF Workshop on Monocrystal Technology", 1974.

(19) Benz, K., "Growth of Single Crystals of Electronic Materials Under Space Environment", ESRO Space Processing Symposium, Frascati, Italy, March, 1974.

(20) Lundquist, C. A., "Skylab Experiments on Semiconductors and Alkali Halides", NASA/MSFC/LLS, ESRO Space Processing Symposium, Frascati, Italy, March, 1974.

Abstract: Description of results of the six Skylab crystal growth experiments.

(21) Li, C. H., "A New Mechanism for the Formation of Growth Spirals", Grumman, Bethpage, N. Y., Journal of Applied Physics, Vol. 45, No. 15, May, 1974, 4 pgs.

(22) Carruthers, J. R., Witt, A. F., "Transient Segregation Effects in Czochraski Growth," Bell Labs/MIT, Proceedings of the 2nd International Spring School on Crystal Growth, North Holland Publications, 1975.

(23) Witt, A. F., et al., "Crystal Growth and Steady State Segregation Under Zero Gravity", Journal of Electrochemical Society, Vol. 122, 1975, pgs. 276-283.

(24) Lefever, R. A., "Mixed III-V Crystal Growth in Very Low Acceleration Fields", USC, Los Angeles, CA, Contract NASA8-28305, 1975.

Section IV. D. 1.

(25) Papazian, J. M., Kattamis, T. Z., "Flight I Technical Report on Experiment 74-37-Contained Polycrystalline Solid in Low-Gravity", Grumman, Bethpage, N. Y., NASA Contract NAS8-31530, Grumman Report RM-617, April, 1967.

Abstract: Preliminary results of SPAR I experiment 74-37.

(26) Weiss, H., "Criteria for Selection of Crystal Growth Techniques," Universitat Erlangen-Nurnberg, Evlangen, Germany, Second European Symposium on Material Sciences in Space, Frascati, Italy, April, 1976.

(27) Muller, G., "Crystal Growth at Gravity Greater than 1G", Universitat Erlangen-Nurnberg, Erlangen, Germany, Second European Symposium on Material Sciences in Space, Frascati, Italy, April, 1976.

Abstract: Report on preparation of experiment to be performed at variable accelerations above 1g.

(28) Benz, K. W., Weiss, H., "Crystal Growth of III-V Semiconductors Under 0-g Conditions", Universitat Stuttgart, Germany, Second European Symposium on Material Sciences in Space, Frascati, Italy, April, 1976.

Abstract: Methods of growth and effects of Microgravity are discussed.

(29) Rodot, H., "Budgeman Technique in Space: Problems Related to Material Positioning in the Case of Volatile Components", C.N.R.S., Meudon-Bellarie, France, Second European Symposium on Material Sciences in Space, Frascati, Italy, April, 1976.

(30) Nielsen, K. F., "Diffusion Growth of Organic Change-Transfer Crystals", Technical University of Denmark, Second European Symposium on Material Sciences in Space, Frascati, Italy, April, 1976.

Section IV.D.1.

(31) Witt, A. F., "Overview of Crystal Growth Experiments on ASTP", MIT, Cambridge, Mass., Second European Symposium on Material Sciences in Space, Frascati, Italy, April, 1976.

Abstract: Review of experiment results for ASTP experiments: MA060 (Melt Growth), MS085 (Vapor Growth), MA-028 (Solution Growth).

(32) Ulrich, D. R., et. al., General Electric "Crystal Growth in Fused Solvent Systems", Nov. 1974, NAS8-28114.

2. SOLUTION GROWTH

(1) Dunacan, C. S., Rubenstein, M., Seidensticker, R. G., "Optimization of a Solution Growth Experiment for Zero Gravity and Development of Apparatus for a Melt Growth Experiment", Westinghouse, NASA Contract NAS8-26122, Final Report, NASA-CR-119792, 1971.

(2) Miyagawa, I., "Investigation of Crystal Growth from Solutions", UAH, Huntsville, AL, Contract NAS8-28098, ALA-U-BER-8-28098-PR, Jan. 1972.

(3) Doty, J. P., Reising, J. A., "Study of Single Crystals of Metal Solid Solutions", Eagle-Picher Inc., Dedham, Mass., Contract NAS8-29077, Final Report, NASA-CR-124354 (73N 29532), May 1973, 86 pgs.

Abstract: Silver, copper, gold and their alloys investigation to develop background information to support space flight experiment and generate ground based data for comparison.

(4) Griesenauer, N. M., Miller, J. F., "Single Crystals of Metal Solid Solutions", Battelle, Columbus, Ohio, Contract NAS8-29875, BMI9-29875-MLPR, Nov. 9, 1973.

(5) Bannister, T. C., "Rochelle Salt Growth - TV-105", NASA/MSFC/SSL, Skylab III and IV Science Demonstrations Preliminary Report, NASA-TM-X-64835, March, 1974, pgs. 17-19.

Section IV. D. 2.

(6) Bannister, T. C., "Deposition of Silver Crystals - TV106", NASA/MSFC/SSL, Skylab III and IV Science Demonstrations Preliminary Report, NASA-TM-X-64835, March, 1974, pgs.19-21.

(7) Grodzka, P. G., Facemire, B., "Growth of Silver Crystals Aboard Skylab IV", LMSC, NASA/MSFC, Quick-Look Report, March, 1974, 11 pgs.

Abstract: Report on preliminary results of science demonstration TV-106, silver crystals grown by electrochemical deposition of silver ion from solution by copper.

(8) Miyagawa, I., "Investigation of Crystal Growth from Solutions", UA, Tuscaloosa, AL, Contract NAS8-28098, Final Report, Oct., 1975, 224 pgs.

Abstract: Investigation of the effects of convection of crystal properties. Crystal growth from solution is discussed, in particular the Rochelle salt crystals grown on Skylab IV.

3. MELT GROWTH

(1) Fullmer, L. D., Housley, R. M., "Crystal Growth from Melts in Zero-G Environment", NAR, Thousand Oaks, CA, (70N20540), Feb. 5, 1970, 7 pgs.

Abstract: Value of perfect single crystals, factors limiting perfection, and a crystal pulling apparatus are discussed.

(2) Roy, U., "Single Crystal Growth from Melt under Space Environment", UAH, Huntsville, AL, (70N20542), Feb. 5, 1970, 20 pgs.

Abstract: Brief outline of normal gravity single crystal growth from melts. Review effects of interface shape, high-g, gamma-ray, and electromagnetic body forces. Proposed experiment to study growth kinetics in equivalent gravity fields.

Section IV. D. 3.

(3) Duncan, C. S., Rubenstein, M., Seidensticker, R. G., "Optimization of a Solution Growth Experiment for Zero Gravity and Development of Apparatus for a Melt Growth Experiment", NASA Contract NAS8-26122, NASA-CR-119792, 1971.

(4) Kim, K. M., Witt, A. F., Gatos, H. C., "Crystal Growth from the Melt Under Destabilizing Conditions", MIT, Cambridge, Mass., Journal of Electrochemical Society, Vol. 119, 1972, p. 1218.

(5) Gatos, H. C., Witt, A. F., "Apollo Indium Antimonide Remelt Experiment", MIT, Cambridge, Mass., Contract NAS8-28189, MIT-28280-FR, Oct., 1972.

(6) Walter, H. U., "Seeded, Containerless Solidification of Indium Antimonide", UAH, Huntsville, AL, Third Space Processing Symposium: Skylab Results, Vol. 1, M-74-3, June, 1974, pgs. 257-274.

Abstract: Preliminary results of Skylab experiment M560.

(7) Witt, A. F., Gatos, H. C. Lichtensteiger, M., "Steady State Growth and Segregation under Zero Gravity:InSb", MIT, Cambridge, Mass., Third Space Processing Symposium: Skylab Results, Vol. I, M-74-5, June, 1974, pgs. 275-301.

Abstract: Preliminary results of Skylab experiment M562.

(8) Yee, J. F., Sin, S., Samra, K., L ', M., Wilcox, W. R., "Directional Solidification of In Sb-GaSb Alloys", UCLA, Third Space Processing Symposium: Skylab Results, Vol. I, M-74-5, June, 1974, pgs. 301-374.

Abstract: Preliminary results of Skylab experiment M563.

(9) Yue, J. T., Voltmer, F. W., "Influence of Gravity - Free Solidification on Microsegregation", TI, Dallas, TX, Third Space Processing Symposium:Skylab Results, Vol. I, M-74-5 June, 1974, pgs. 375-425.

Section IV. D. 3.

(10) Gatos, H. C., Witt, A. F.,"Indium Antimonide Crystal Growth - Skylab Experiment M562", MIT, Cambridge, Mass., Contract NAS8-28306, Final Report, NASA-CR-120558, Sept., 1974, 79 pgs.

Abstract: Results obtained prove the advantageous conditions provided in outer space. Ideal diffusion controlled steady-state conditions were achieved during the growth of Te-doped InSb crystals on Skylab.

(11) Carruthers, J. R., "Crystal Growth form the Melt", Treatise on Solid State Chemistry, Vol. 5, 1975, pgs. 325-406.

(12) Witt, A. F., Gatos, H. C., Lichtenstiger, M., Lavine, M. C., Herman, C. J., "Crystal Growth and Steady State Segregation under Zero Gravity:InSb", MIT, Cambridge, Mass., Journal of Electrochemical Society, Vol. 122, No. 2, February, 1975.

Abstract: Summary of final results of Skylab experiment M562.

(13) Gatos, H. C., Witt, A. F., "Quantitative Determination of Zero Gravity Effects on Electronic Materials Processing - Germanium Crystal Growth with Simultaneous Interface Demarcation", MIT, Cambridge, Mass., NASA Contract NAS8-30576, 1975.

Abstract: Preliminary results of ASTP experiment MA-060.

(14) Witt, A. F., "Detailed Results of ASTP Experiment MA-060", MIT, Cambridge, Mass., Second European Symposium on Material Sciences in Space, Frascati, Italy, April, 1976.

(15) Walter, H. U., "A Mechanism for Generation of Pulsating Growth and Non-rotational Striations in Melt Grown Crystals, I. Initial Transient Region", UAH, Huntsville, AL, Journal of Electrochemical Society (to be published), NASA Contract NAS8-28304.

Section IV. D. 3.

Abstract: New concept derived to explain off-facet striations in InSb Skylab samples. Concept considers decrease of liquidus temperature in the initial transient region.

(16) Walter, H. U., "Growth Rate Oscillations and Pulsations in Melt-Grown Crystals, II. Terminal Transient Region", UAH, Huntsville, AL, Journal of Electrochemical Society (to be published), Contract NAS8-28304.

Abstract: Growth rate oscillations and pulsations may be triggered in the therminal transient region.

4. VAPOR GROWTH

(1) Wiedemeier, H., "Growth of Single Crystals by Vapor Transport in Zero Gravity Environment, Ground Based Experiments", RPI, Troy, N. Y., NASA Contract NAS8-26146, Final Report, NASA-CR-126611 (72X76522), Sept. 1971, 35 pgs.

(2) Wiedemeier, H., et al., "Crystal Growth by Vapor Transport of $GeSe_2$ and GeTe and Transport Mechanism of GeTe", RPI, Troy, N. Y., Journal of Crystal Growth, Vol. 13/14, 1972 pgs. 393-396.

(3) Wiedemeier, H., Klaessig, F. C., Wey, S. J., Irene, E. A., "Vapor Growth of GeSe and Ge Te Single Crystals in Micro-Gravity", RPI, Troy, N. Y., Third Space Processing Symposium: Skylab Results, Vol. I., M-74-5, June, 1974, pgs. 235-256.

Abstract: Preliminary results of Skylab experiment M556. Analysis based on comparison of GeSe and GeTe crystals and mass transport rate data obtained on earth and in space indicate crystals of improved quality could be grown in space by the vapor transport technique.

(4) Wiedemeier, H., Sadeek, H., Klaessig, F. C., Norek, M., "Crystal Growth from the Vapor Phase - ASTP Experiment MA-085", RPI, Troy, N.Y., Contract NAS8-20578, Oct., 1975.

Section IV. D. 4.

Abstract: Post flight preliminary report of ASTC experiment MA-085.

(5) Belouet, C., "Review of European Proposals for Vapour Growth", Laboratoires d'Electronique et de Physique Appliquée , Limeil- Bre'vannes, France, Second European Symposium on Material Sciences in Space, Frascati, Italy, April, 1976.

Abstract: Description of the European tentative proposals for the first Spacelab flight.

(6) Wiedemeier, H., "Crystal Growth from the Vapor Phase ASTP Experiment MA-085", RPI, Troy,N. Y., Second European Symposium on Material Sciences in Space, Frascati, Italy, April, 1976.

5. ANALYSIS

(1) Burkhard, D. G., Sexl, H., Sexl, R., "Study of Interfacial Conductivity", P.E.C. Research Associated, Louisville, Colorado, Contract NAS8-30171, NASA-CR-102989 (71N15601), 1970, 149 pgs.

Abstract: Results of literature survey on the theory of crystal growth in zero gravity. Expansion of statistical theory of interfacial thermal conductivity.

(2) Arnett, G. M., Kulshreshtha, A. P., Mookherji, T., "Techniques for Characterization and Evaluation of Zero Gravity Grown Gallium Arsenide", (70N20534), Feb. 5, 1970, 17 pgs.

Abstract: Brief discussion of modern techniques to detect ultratrace impurities and dislocation-type imperfections influencing electronic properties of gallium arsenide.

(3) Davis, J. H., "An Analytical Experimental Study of Possible Effects ofGravity on Crystal Whiskers", NASA TMX 53993, Feb., 1970, p. 422.

Section IV. D. 5.

(4) "Ellipsometric Measurements of Epitaxial GaAs Layers on a GaAs Substate", UAH, Huntsville, AL Contract NAS8-29494, ALA-U-BER-8-29494-PR, April 29, 1973.

(5) "Evaluation of Semiconductor Specimens by X-Ray Analysis", UAH, Huntsville, AL, Contract NAS8-29650, ALA-U-RI-8-29650-MTR-1, May, 1973.

(6) "Analytics of Crystal Growth in Space", USC, Annual Report for NASA (5 June 1973 - 5 June 1974), 1974.

(7) Robinson, A. L., "Crystal Growing in Space - Significance Still Up in the Air", Science, Vol. 187, Feb. 14, 1975, pgs. 527-528.

(8) Castle, J. G., "Electrical Characterization of Ga As Single Crystal in Direct Support of M555 Flight Experiment", UAH, Huntsville, AL, Contract NAS8-29542, NASA-CR-143986, Oct., 1975, 60 pgs.

Abstract: Three nondestructive methods of electrical characterization of semiconductor single crystals are discussed.

(9) Wilcox, W. R. Chang, C. E., Lefever, R. A., "Analytics of Crystal Growth in Space", USC, Contract NAS8-29847, Dec., 1975, 115 pgs.

Abstract: Two crystal growth processes under consideration for Spacelab experiments were studied. Computer calculations were performed on transport processes in floating zone melting and crystal growth from solution under low-gravity conditions.

(10) Castle, J. G., Appendix (Bibliography) to Space Processing Crystalline Materials: A Study of Known Methods of Electrical Characterization of Semiconductors, UAH, Huntsville, AL, Contract NAS8-30774, Jan., 1976, 38 pgs.

Abstract: A selected bibliography on known electrical characterization techniques for semiconductors.

PAGE

SECTION V. CONTAINERLESS PROCESSING

A. GENERAL STUDIES

(1) Bunshah, R. F., Juntz, R. S., "Levitation Melting of Berylluim and Aluminum", University of Cal., Livermore, Cal., American Vacuum Society, UCRL-7913 (66N20533), June, 1964, 13 pgs.

(2) Downey, J. W., "Levitation Melting of Metals and Alloys", Argonne National Lab., Ill., ANL-7398 (68N27205), Dec., 1967, 15 pgs.

Abstract: Qualitative evaluation of two levitation coil designs.

(3) Frost, R. T., "Weightless, Containerless Melting and Solidification of Potential New Metal and Ceramic Products", GE, Valley Forge, PA, (71N11706), Oct., 1969, 20 pgs.

Abstract: Super alloy castings with rare earth oxides, metal emulsions casting, ultrapure materials preparation, and solidification with extreme subcooling.

(4) Frost, R. T., Napaluch, L. J.,Wise, T. D., Stockhoff, E., Wouch, G., "Free Suspension Processing Systems for Space Manufacturing", GE, Valley Forge, PA, NASA-CR-119954 (71X10896), June, 1971, 79 pgs.

Abstract: Melt solidification, crystal growth from melt, microstructure formation.

(5) Brashears, M. R., Robertson, S. J., "Research Study on Materials Processing in Space Experiment M512", LMSC, Huntsville, AL, NASA Contract NAS8-28729, NASA-CR-120185 (74N21068), Dec., 1973.

(6) "Containerless Processing in Space", Summary Report, USRA, Prepared for National Academy of Engineering 1974 Summer Study, 1974.

Abstract: Introduction to containerless processing, techniques for positioning and manipulation in zero-g, and possible applications.

B. POSITION/CONTROL TECHNIQUES

1. GENERAL

(1) Berge, L. H., "Positioning and Handling in Weightless Environment", NASA/MSFC, Unique Manufacturing Processes in Space Environment, (71N26014), April, 1970, 8 pgs.

Abstract: Description and application of electro-mechanical transfer, positioning and retrieving devices for an orbiting manufacturing facility.

2. ACOUSTIC FIELDS

(1) Whymark, R. R., "Design, Development, Fabrication, and Test of Acoustic Processors", Interand Corp., Contract NAS8-28762, Interand 8-28762-MR, July 14, 1972.

(2) Whymark, R. R., "Operating Instructions for the Acoustic Processors", Interand Corp., Interand 8-28762-OI, Jan. 26, 1973.

(3) Whymark, R. R., "Acoustic Processing Method for MS/MS Experiments", Interand Corp., NASA-CR-124300 (73N28671), June, 1973, 46 pgs.

Abstract: Single sound beam positioning control: description and experimental rrsults.

(4) Wang, T. G., Saffren, M. M., Elleman, D. D., "Material Suspension within an Acoustically Excited Resonant Chamber", JPL, Pasadena, Cal., NASA-CASE-NPO-13263-1 (73N31443), Aug., 1973, 27 pgs.

Abstract: Patent application. Acoustic transducers establish a standing wave pattern in a rectangular furnace chamber to position an object under low gravity conditions.

(5) Whymark, R. R., "Acoustic Positioning for Space Processing Experiments", Interand, Corp., NASA Contract NAS8-30471, Intersonics 8-30471-MPR-1, Dec., 1973.

Section V. B. 2.

(6) Wang, T. G., Saffren, M. M., Elleman, D. D., "Acoustic Chamber for Weightless Positioning", JPL, Institute of Technology Pasadena, Cal., 12th AIAA Aerospace Sciences Meeting, Washington, D. D., AIAA Paper 74-155 (74A20769), Jan., 1974, 6 pgs.

Abstract: Design of a resonator to position molten materials in an extreme temperature gradient and a servo loop to maintain position as temperature varies.

(7) Whymark, R. R., "Acoustic Positioning for Containerless Processing", Intersonics Corp., The Proceedings of the Third Space Processing Symposium, Vol. II, M-74-5, June, 1974, pgs. 647-679.

Abstract: Description of a new non-contact positioning device for space processing. Containerless melting and solidification can be performed and a freely suspended liquid can be shaped to the contour of the sound field.

(8) Wang, T. G., Saffren, M. M., Elleman, D. D., "Acoustic Positioning Chamber for Space Processing", JPL, Pasadena, Cal., Third Space Processing Symposium, Vol. II, M-74-5, June, 1974, pgs. 679-691.

Abstract: By readily levitating, positioning, and manipulating materials placed in it, the acoustic resonator can serve a variety of space processing operations, such as drawing crystals, degassing and stirring of melts, and casting.

(9) Lierke, E. G., "Hardware Development and Performance Tests for Acoustic Positioning Device", Battelle Institut, Frankfurt, Germany, Second European Symposium on Material Sciences in Space, Frascati, Italy, April, 1976.

Abstract: Description of newly developed furnace utilizing acoustic positioning techniques.

Section V. B. 3.

3. ELECTROMAGNETIC FIELDS

(1) Pfann, W. G., dazelbarger, D. W., "Electromagnetic Suspension of a Molten Zone", Journal of Applied Physics, Vol. 27, No. 12, 1956.

(2) Hatch, A. J., "Potential-Well Description of Electromagnetic Levitation", Argonne National Lab., Argonne, Ill., Journal of Applied Physics, Vol. 36, (65A15820), Jan., 1965, 9 pgs.

Abstract: Derivation of levitation forces exerted by spatially non-uniform arc magnetic fields on nonmagnetic conducting spheres as the negative gradient of a potential function.

(3) Nix, G. F., Piggott, L. S., "Electromagnetic Levitation of a Conderating Cylinder", University of Manchester, England, Proceedings of Institution of Electrical Engineers, Vol. 113, (66A35729), July, 1966, 7 pgs.

Abstract: Long circular cylinder supported by a.c. field produced by two conductors paralled to the cylinder axis. Boundaries for the stable float region were determined for 2 cm diameter aluminum bar with wires 2, 4 and 6 cm apart with ac frequency at 50,400 and 2,000 Hz.

(4) Furth, H. P., "Some Engineering Applications of High Magnetic Fields", Princeton University, N. J., 6th Annual Meeting of Society of Engineering Science, (70A37948), Nov., 1968, 9 pgs.

Abstract: Brief review of high magnetic pressure application, particularly metal forming by pulsed 100 kilogauss magnetic fields and levitation of superconducting rings by 10 kG static magnetic fields.

Section V. B. 3.

(5) Cornish, D. N., "A Report on the Culham Superconducting Levitron", Atomic Energy Research Establishment, Berkshire, England, 2nd International Symposium on Electro-Magnetic Suspension, Southampton, England, (72A24758), July, 1971, 12 pgs.

Abstract: Discussion of machine for trapped hot plasma stability and confinement studies in vacuum, emphasizing superconducting aspects and coil performance.

(6) Clark, M. F., "Design, Development, Fabrication, Assembly, and Testing Support for a Free Suspension Processing System for Space Manufacturing Utilizing Electromagnetic Force Field", NASA Contract NAS8-27228, GE-8-27228-SR, Dec., 1971.

(7) Buerger, E. H., et al., "Electromagnetic Free Suspension System for Space Manufacturing", GE, Valley Forge, PA, NASA Contract NAS8-27228, Final Report, NASA-CR-124134 (N73-20522), Dec., 1972, 158 pgs.

Abstract: Four coil optimization, four vs. six coil comparison; four coil position servocontrol and breadboard; position sensing servosystem; two color pyrometer, and specimen toration mode analysis.

(8) Frost, R. T., "Study of a Free Suspension System for Space Manufacturing - Phase B", GE, Valley Forge, PA, NASA Contract NAS8-29780, GE8-29680-MPR-1, Sept., 1973.

(9) Frost, R. T., et al., "Electromagnetic Containerless Processing Requirements and Recommended Facility Concept and Capabilities for Spacelab", NASA Contract NAS8-29680, GE-8-29680-FR, May, 1974.

(10) Wouch, G., Okress, E. C., Frost, R. T., Rutecki, D. J., "Electromagnetic Levitation Facility Incorporating Electron Beam", GE, Valley Forge, PA, Rev. Sci, Instrum, Vol. 46, No. 8, August, 1975.

C. HEATING/COOLING TECHNIQUES

1. GENERAL

(1) Rasquin, J. R., "Heat Sources for Space Manufacturing Processes", NASA/MSFC, Space Processing and Manufacturing Meeting, (70N14673), Oct., 1969, 8 pgs.

Abstract: Assessment of available heat sources for zero-gravity processing: weight, bulk, power, reliability, safety, and cost.

2. INDUCTION HEATING

(1) Golovin, G. F., "Application of Induction Heating in Micro-Metallurgy", Joint Publications Research Service, Washington, D. C., JPRS-29213, TT-65-30553, (65N19539), March, 1965, 50 pgs.

Abstract: Translated from Russian. Crucible-less electromagnetic levitation and heating.

3. ELECTRON BEAM

(1) Paton, B. YE., et al., "The Special Features of the Procedure and Equipment for Electron Beam Welding and Cutting under Space Conditions", Institute Elektrovarki, Kiev, USSR, Automaticheskaia Svarka, Vol. 3, No. 3, 72A25809, Feb., 1962, 6 pgs.

Abstract: (In Hungarian) Equipment design features and performance. Results of use with alloy steels and aluminum alloys in zero and normal gravity.

(2) Thornhill, J. W., "Material Processing and Phenomena Investigations for Functional Electronic Blocks, Westinghouse, Pittsburgh, PA, AD-476728 (66X15268), Jan., 1966, 92 pgs.

Abstract: Electrochemical and electron beam techniques in material processing. Some key words: Boron, electrophoresis, etching, silicon.

Section V. C. 3.

(3) "Studies in Electron-Beam Melting in Metals", Joint Publications Research Service, Washington, D. C., JPRS-34181 (66N19021), Feb., 1966, 26 pgs.

Abstract: Translation from Russian. Electron beam melting of ball bearing steel (Yu.M. Yebiemenko). Preferential growth in molybdenum single crystals from electron beam, levitation zone recrystalization (A. L. Pekerov et al). Single crystals of refractory metals (Ye. M. Savitsky, et al).

(4) Hassan, C. B., Lienaw, H. G., Lowry, J. F., "Electron-Beam Welder for Use in Space", Westinghouse, Pittsburgh, PA, NASA/MSFC, 9th Annual IEEE Symposium on Electron, Ion, and Laser Beam Technology, Berkley, CA, (68A23700), May, 1967, 5 pgs.

Abstract: Description of battery operated laboratory and second generation flight models.

(5) Hassan, C. B., Lienaw, H. F., Lowry, J. F., "Adaptation of a Battery-Powered Electron Beam Device to Perform an In-Orbit Welding Experiment", 9th Annual IEEE Symposium on Electron, Ion, and Laser Beam Technology, Berkley, CA, (68A27477), May, 1967, 15 pgs.

Abstract: A 60 lb., 2-kw, 20 kv electron beam device is discussed.

(6) Paton, B. YE., et al., "Electron Beam Welder for Space", Joint Publications Research Service, Washington, D. C., Akademua Nauk Ukrainskoi, USSR, (71N25239), May, 1971,11 pgs.

Abstract: Translated from Russian. Comparison of results of laboratory and Soyuz 6 operations of maneuverable thin sheet metal cutter/welder.

(7) "Develop of High Intensity Electron Gun", Georgia Institute of Technology, Atlanta, GA, NASA Contract NAS8-29860, July, 1973.

Section V. C. 4.

4. SOLAR ENERGY

(1) Hoez, M., Foex, M., "Remards Concerning Solar Furnaces in Space", Laboratoire des Ultra-Refractaries, France, Solar Energy, Vol. 13, (72A37675), July, 1972, 4 pgs.

Abstract: Orbital or lunar high temperature processing opportunities and problems with refractory metals (tungsten, tantalum, iridium).

(2) Frantsevich, I. N., Dvernaikov, V. S., Pasichnyi, V. V., Shigahov, N. A., Korunov, IV. I., "Investigation of the Possibility of Using Radiant Solar Energy for Welding and Soldering of Materials", Akademiia Nauk, Ukrainskoi, Kiev, USSR, 23rd IAF International Congress, Vienna, Austria, (72A45126), Oct., 1972, 10 pgs.

Abstract: (In Russian) Description of equipment used for solar energy welding, soldering and heat treating. Parabolic 2 meter reflector produced 20 k cal/sq. cm./min. Test data for tubular steel and titanium alloy.

5. LASER

(1) Downs, W. R., "Chemical Laser", NASA/JSC, NASA-CASE-MSC-10986-2 (72N25489), Jan., 1972, 27 pgs.

Abstract: Patent Application. High intensity chemical lasers for continuous use in zero or low gravity applications.

6. WELDING STUDIES

(1) Paton, B. . . et al., "Experiment on the Welding of Metals in Space", Visn. Akad, Nauk Ukraninsoki USSR, Kiev, USSR, Joint Publications Research Service, JPRS-51149 (70N35553), Aug., 1970, 6 pgs.

Abstract: Electron beam welding and cutting, low pressure plasma arc welding and cutting, and arc welding with fused electrode were investigated in weightlessness. Translated into English.

Section V. C. 6.

(2) Andrews, J. B., Arita, M., Masubuchi, K., "Analysis of Thermal Stress and Metal Movement During Welding", MIT, Cambridge, Mass., NASA-CR-61351 (N71-26143), Dec., 1970, 279 pgs.

Abstract: Analysis and control of distortion during welding. Theoretical background for calculation of temperature and stress distribution. Materials studies include aluminum, steel, columbium, and tantalum.

(3) Masubuchi, K., "Integration of NASA-Sponsored Studies on Aluminum Welding, MIT, NASA-CR-20641(N72-26376), June, 1972, 321 pgs.

Abstract: Effects of porosity on weld joint performance, sources of porosity, weld thermal effects, residual stresses and distortions, and manufacturing process system control.

(4) Wilsner, P., "Spacecraft Soyuz 6 and the Welding Experiment", Air Force Systems Command, Wright Patterson AFB, Ohio, AD-749745, FTD,HC-23-1089-72, (73N14496), July, 1972, 8 pgs.

Abstract: Plasma Arc, electron-beam, and consumable electrode arc welding. Translated into English.

(5) Poorman, R. M., "Skylab M551 Metals Melting Experiment", NASA/MSFC, NASA-TM-X-64960, May, 1975, 26 pgs.

Abstract: Final Report of the Skylab M551 Metals Melting Experiment prepared by the Principal Investigator.

D. APPLICATION STUDIES

1. GENERAL

(1) Frost, R. T., Napoluch, L. J., Wise, T. D., Stockhoff, E., Wouch, G., "Free Suspension Processing Systems for Space Manufacturing", GE, Valley Forge, Contract NAS8-26157, NASA-CR-119954 (71X10896), June 15, 1971.

(2) "Development of Containerless Process for Preparation of Tungsten with Improved Service Characteristics", GE, Valley Forge, PA, GE8-29879-MPR-1, NASA Contract NAS8-29879, March 31, 1974.

(3) Wouch, G., Bloom, H., "Free Suspension Processing- A Review of Selected User Interests and Requirements", GE, Valley Forge, PA, AIAA/ASME 1974 Thermophysics and Heat Transfer Conference, Boston, Mass., AIAA Paper 74-649, July, 1974.

Abstract: Specific processing needs to 18 representative materials/combinations likely to be processed advantageously in weightlessness of space flight using electromagnetic positioning and heating.

(4) Frost, R. T., "Design Analysis of Levitation Facility for Space Processing Applications", GE, Valley Forge, PA, NASA Contract NAS8-29680, Final Report, Nov., 1974, 120 pgs.

Abstract: Work concerns further definition of a containerless processing facilities for the Space Laboratory and Space Shuttle. Four material process examples were studies as representative with severe requirements for the facility in areas such as power, heat dissipation, etc.

(5) Treverton, J. A., Margrave, J. L., "Levitation Calorimetry, IV - Colbalt and Palladium", Rice University, Houston, TX, Journal of Physical Chemistry, Vol. 75, (72A34025), Nov., 1975, 4 pgs.

Abstract: Specific heats, heats of fusion, and surface emmissionities.

Section V. D. 2.

2. SINGLE CRYSTAL PROCESS

(1) Pekarev, A. I., Chistyakov, Yu, D., Schirenko, G. N., "Statistical Analysis of the Directions of Preferential Growth in Molybdenum Single Crystals Obtained by Electron Beam, Livitation Zone Recrystallization", Studies in Electron-Beam Melting of Metals, Joint Publications Research Service, Washington, D. C., (66N19023), Feb., 1966, 8 pgs.

Abstract: Translated into English. Based on 67 single crystals of molybdenum.

(2) Halter, H. U., "Seeded Containerless Solidificat[illegible] Indium Antimonide", Proceedings of the Third Space [illegible]rocessing Symposium, Vol. I, M-74-5. June, 1974, pgs. 257-273.

Abstract: Directional solidification of a containerless melt that was suspended at the end of a seed crystal was employed to produce crystals of InSb during Skylab missions (SL3 and SL4).

PAGE

SECTION VI. GLASS AND CERAMIC MATERIAL PROCESSING

A. GENERAL STUDIES

(1) Happe, R. A., "Possibilities of Producing New Glasses in Space", NAR, Downey, Cal., Space Processing and Manufacturing Meeting, NASA/MSFC, ME69-1 (70N14658), Oct., 1969, 10 pgs.

Abstract: Superheating and cooling without normal necleation sites (i.e. container walls) may permit glass production from normally crystalline materials such as Al_2O_3, HfO_2, ZrO_2, etc.

(2) Frost, R. T., "Weightless, Containerless Melting and Solidification of Potential New Metal and Ceramic Products", GE, Valley Forge, PA, Space Processing and Manufacturing Meeting, NASA/MSFC, ME69-1, (70N14656), Oct., 1969, 20 pgs.

Abstract: Super alloy castings with rare earth oxides, metal emulsions casting, ultrapure materials preparation, and solidification with extreme subcooling.

(3) Deeg, E. W., "Glass Preparation in Space", American Optical Co., Southbridge, Mass., Space Processing and Manufacturing Meeting, NASA/MSFC, (70N20519), Feb., 1970, 18 pgs.

Abstract: Crucible free melting, glasses sensitive to thermal convection, lenses and mirror blanks with fire polished surfaces direct from melt, dispersion filters, nucleation control through solid power dispersion.

(4) Happe, R. A., "Possibilities for Producing New Glasses in Space", NAR, Downey, Cal., Space Processing and Manufacturing Meeting, NASA/MSFC, (70N20524), Feb., 1970, 30 pgs.

Abstract: Superheating and cooling without normal nucleation sites (i.e. container walls) may permit glass production for normally crystalline materials such as Al_2O_3, HfO_2, ZrO_2, etc.

(5) Happe, R. A., "Implications of Zero Gravity for Producing New Glasses in Space", Journal of Non-Crystalline Solids, Vol. 3., No. 4, 1970, p. 375.

Section VI. A.

(6) Brandt, R. C., Dennis, M. D., "Microstructure and Reflectance of $PbO-B_2O_3-SiO_2$ Glass with Crystalline Opacifier Additions", Pennsylvania State University, PA, American Ceramic Society Journal, Vol. 54, (71A28990), May, 1971, 4 pgs.

Abstract: Maintenance of two-phase immiscibility is essential to opacity.

(7) Happe, R. A., "Study of the Production of Unique New Glasses", NAR, Downey, Cal., NASA Contract NAS8-28014, NASA-CR-123740 (72N28564), June, 1975, 153 pgs.

Abstract: Preliminary study of processing equipment for new glass production in zero gravity. Induction and laser melting are preferred. Calculation of power for melting and calculation of cooling rates.

(8) Happe, R. A., Topoe, L. E., "Experiments Leading to the Production of New Glasses in Space", NAR, Downey, Cal., 12th Aerospace Sciences Meeting, Washington, D. C., AIAA Paper 74-159, 74A18862, Jan., 1974, 7 pgs.

Abstract: Free-fall cooled spherules of previously unreported glassy-state composition were produced from laser melted spinning ceramic-oxide rods.

(9) Larson, D. C., Crandall, W. B., "Space Processing of Chalcogenide Glasses", ITT Research Institute, Chicago, Ill., NASA Contract NAS8-30627, Contractor Report ITTRI8-30627-MPR-1, March, 1974.

(10) Happe, R. A., Topoe, L. E., "Oxide Glass Processing", NAR, Downey, Cal., Proceedings of the Third Space Processing Symposium: Skylab Results, Vol. II, M074-5, June, 1974, pgs. 887-924.

Abstract: The absence of a mold in space processing offers no heterogenous nucleation sites. New glasses with interesting combinations of optical properties e.g. index of refraction and dispersion, then might be produced.

Section VI. A.

(11) Larsen, D. C., "Theoretical Study of the Production of Unique Glasses in Space", First Annual Report, NASA Contract NAS8-29850, IITRI Project D6807, July, 1974.

(12) Russak, M. A., "Quantitative Analysis of Nepheline Glass-Ceramics by X-Ray Diffraction", Journal of American Ceramic Society, Vol. 57, No. 11, 1974, pgs. 500-501.

(13) "Preparation of Glasses and Ceramic Materials - Summary Report", Prepared by USRA Glass Committee for National Academy of Engineering 1974 Summer Study, 1974, pgs. 69-92.

Abstract: Summary discussions of state of the art technology in glass and ceramic preparation, applicability to space processing, potential applications.

(14) Russak, M. A., Kivlighn,H. D., Jr., "Crystallization and Microstructure of Nepheline Glass-Ceramics", Grumman Aerospace, Bethpage, N. Y., Grumman RD Memorandum RM-595, Jan., 1975. 16 pgs.

Abstract: Study to determine effects of processing glass-ceramic materials in low-gravity environment.

(15) Kinser, D. L., "Study of Diffusion Coefficients of Glasses Under Zero-G", Vanderbilt University, Nashville, TN, NASA Contract NAS8-30656, Interim Report, Feb., 1975,12 pgs.

Abstract: The work involves the premise that diffusion studies of the glass forming ion can be examined in zero-gravity environments and diffusion data obtained from these experiments will be unique because of earth based experimental problems.

(16) Gelles, S. H., Malik, R. K., "Process Development for Producing Fine-Grain Castings in Space", Battelle, Columbus, Ohio, NASA Contract NAS8-29626, Final Report, April, 1975, 59 pgs.

Section VI. A.

(17) Ali, M. A., Larsen, D. C., "Space Processing of Chalcogenide Glass", ITTRI, Chicago, Ill, NASA Contract NAS8-30627, Annual Report, March 11, 1976, 48 pgs.

Abstract: Chalcogenide glasses are considered as potential candidate materials for use as laser windows and infared fiber optics. This project is being conducted to investigate space processing of chalcogenide glasses.

(18) Deutscher, E., "Interest in Solidification of Glasses and Ceramics in Space", Ernest Leitz GmbH, Watzlar, Germany, Second European Symposium on Material Sciences in Space, Frascati, Italy, April, 1976.

Abstract: A programme for pre-studies of space processing based on German experiment proposals in the field of glasses and ceramics has been recommended.

B. METHODS OF PREPARATION

1. GENERAL

(1) Bowers, D. J., "A Critical Complication of Ceramic Forming Methods - Miscelleneous Forming Methods", American Ceramic Society Bulletin, Vol. 44, (65A16831), Feb., 1965, 6 pgs.

Abstract: Forming from vapors, foamed ceramics, fibers, bulk placement and molding, impregnation, reaction sintering, high-energy-rate forming, electrophoretic forming, and machining and grinding.

(2) Larsen, D. C., "Theoretical Study of Producing Glasses in Space", ITTRI, Chicago, Ill., Contract NAS8-29850, Contractor Report No. ITT-RI-D6087, July 31, 1973.

(3) Paule, R. C., Early, J. G., Boettinger, W. J., "Evaporative Preparation of Ultrahigh Purity Material", National Bureau of Standards, Washington, D. C., 1974.

2. SLIP CASTING

(1) Adams, E. F., "Slip-Cast Ceramics", Corning Glass Works, Corning, N. Y., High Temperature Oxides, Part 4, Academic Press, N. Y., (72A24733), 1971, 40 pgs.

Abstract: To consolidate ceramic, cermet, and metal powders to high density; slurry process, chemistry of deflocculation, particle size distributions, rheology, binders, mixing, molding and the casting process.

3. LASER SPIN-MELTING

(1) Topoe, L. E., et al., "Formation of New Oxide Glasses by Laser Spin Melting and Free Fall Cooling", Journal of Non-Crystalline Solids, Vol. 12, 1973, p. 377.

Section VI. B. 3.

(2) Topoe, L. E. Happe, R. A., "Formation of New Lanthanide Oxide Glasses by Laser Spin Melting and Free Fall Cooling", Journal of Non-Crystalline Solids.

(3) Topoe, L. E., Happe, R. A., "Preparation of New Oxide Glasses by Laser Melting", NAR, Downey, Cal., Technical Report SD74-SA-0022.

PAGE

SECTION VII. ELECTROPHORETIC, CHEMICAL AND BIOCHEMICAL PROCESSES

A. GENERAL SEPARATION STUDIES

(1) Hudson, V., Mitchell, R. C., Stark, J. A., White, R. C., "Study of Zero-Gravity, Vapor/Liquid Separators", GD, San Diego, Cal., NASA-CR-71624 (66N22825), Jan., 1966, 146 pgs.

Abstract: Study of heat exchange, mechanical, dielectrophoresis, surface tension, and rotation methods of separation.

(2) Griffin, R. N., McCreight, L. R., "Unit Separation Processes in Space", GE, Valley Forge, PA, Space Processing and Manufacturing in Space Meeting, NASA/MSFC, (70N14662), Oct., 1962, 22 pgs.

Abstract: Centrifugation and electrophoresis, freeze drying and ultraviolet sterilization.

(3) Taylor, T. B., "On the Production and Separation of Industrially Useful Isotopes in Space", International Research and Technology Corp., Washington, D. C., (70N20548), Feb. 5, 1970, 10 pgs.

Abstract: Orbital facility with solar powered electrical generator and partical accelerator emphasizing production of plutonium or U-235.

(4) "Soret Separation in Zero Gravity", LMSC, Huntsville, AL, Contractor No. LMSC/HREC 8-29609-BIMPR, NASA Contract NAS8-29609, July, 1973.

(5) Grodzka, P. G., "Clausius-Dickel Separations (CDS): A New Look at an Old Technique", LMSC, Huntsville, AL, NASA Contract NAS8-29609, Contractor Report LMSC-HREC-TR-D496521, Sept., 1975, 65 pgs.

Abstract: Re-examination of separation technique for possible use in space processing.

(6) Peeters, H., "Separation of Biological Materials in Space", Simon Steirn Institute, Brugge, Belgium, Second European Symposium on Material Sciences in Space, Frascati, Italy, April, 1976.

Section VII. A.

Abstract: Separation methods to be used during experiments in space biology are reviewed.

B. ELECTROPHORETIC METHODS

1. GENERAL STUDIES

(1) Mel, H. C., "Free Boundary Migration and Fractionation of Cell Mixtures - Sedimentation and Electrophoresis", California University, (63N15319), Contractor Report Nos. UCRL-10640, W-7405-ENG-48.

(2) Bhattacharya, A. K., Dumar, A., "Study of Electrophoretic Mobility of Colloidal Particles by Method of Dislocation of Boundaries", USAF, Wright Patterson AFB, Ohio, FTD-MT-63-263(65N11584), March 30, 1964.

(3) Allison, W. S., Kaplan, N. O., "The Comparative Enzymology of Triosephosphate Dehydrogenase", Brandeis University, Waltham, Mass., Bio. Chem., Vol. 239, NSG-375-N1H CA-03611(64N32048), July, 1964.

(4) Graham, B., "Studies on the Hill Reaction Activity of Soluble Chloroplast Extracts," Stanford Research Inst., Menlo Park, Cal., NASA-CR-58340 (64N28935), Aug., 1964.

(5) "Electrophoresis, "Articles from 1964 USSR Medical Encyclopedia, Joint Publications Research Service, Washington, D. C., (65N15722), Oct. 27, 1964.

(6) Kuo, C. Y., "Unconvectional Methods for Influencing Fluid Flow - Part IV, High Field Electrophoresis of Solid Spherical Particles in Low Conductivity Liquids", Carnegie Institute of Technology, Pittsburgh, PA, AF APL-TK-64-133 (66N22422), November, 1965.

(7) Spivack, M. A., "Effect of X-Radiation Upon the Electrophoretic Mobility of Silver Iodide Colloids", Columbia University, N. Y., (6835061), 1966.

(8) Everaerts, F. M., "Displacement Electrophoresis in Narrow Hole Tubes", Technische Hogeschool, Endhoven, Netherlands, (68N17395), 1967.

Section VII. B.

(9) Hankins, B. K., "Orientation of Dielectric Liquids in Low Gravity by Electric Phenomena", Boeing Company, Seattle, Wash., D2-84161-1 (67X16767), Feb., 1967.

(10) Martin, L. L., "Electrophoretic Behavior of Alumina Suspensic. ", Illinois University, Urbana, Ill., (69N20752), 1968.

(11) Lieberstein, H. M., "Some Clarification in the Mathematical Theory of Electrophoresis", Mathematics and Biology Corp. Benton, Kansas, NASA-CR-96461 (68X19239), Aug., 1968.

(12) Nikolov, S. KH, "Effect of Low-Frequency Ultrasound on Electrophoretic Properties and Thermosensitivity of Human Serum Proteins", Biulleten' Eksperimental NoI Biologii I Meditsing, Vol. 68, (70A19470), Sept. 1969.

(13) "Study of Zero-G Fluid Electrophoresis", General Electric, Valley Forge, PA, NASA Contract NAS8-24683, 1970.

(14) McKannan, E. C., Krupnick, A. C., Griffin, R. N., McCreight, L. R., "Electrophoresis Separation in Space - Apollo 14", NASA-TMS-64611, Aug. 29, 1971.

Abstract: Experiment to demonstrate principle and possible problems. Color photographs of separation.

(15) Snyder, R. S., "Electrophoresis Demonstration on Apollo 16", NASA/MSFC, TM-X-64724 (73N18157), Nov., 1972.

Abstract: Free fluid electrophoresis to separate particulate species by surface charge, size or shape. Dye separation was photographed, biological separation was simulated using polystyrene latex.

(16) Micale, F. J., Vanderhoff, J. W., "Electrophoresis Analysis for Apollo 16", Progress Report, NASA Contract NAS8-28654, 1972.

Section VII. B.

(17) Meier, H. V., Dieberg, R., et al., "Separation of Inorganic Ions in Milligram to Decigram Quantities Using Compartmented Electrophoresis", National Lending Library for Science and Technology, Boston, SDA (England), NLL Trans-746-1102-(9022.401), (72N26091), Feb., 1972.

(18) Chanin, L. M., "Research Directed Toward Experimental Investigation of Electrophoresis in Plasmas", Minnesota University Minneapolis, Minn., AD-75786 (73N24739), Dec., 1972.

(19) Dose, K., Rauchfuss, H., "On the Electrophoretic Behavior of Thermal Polymers of Amino Acids", In Molecular Evolution Prebiological and Biological, New York, Plenum Press, (73A17939), 1972.

(20) Mitin, R. V., Priadkin, K. K., Zviaginets, A. V.,"Influence of the Magnetic Field on Electrodeless - Discharge Plasmas", Fizika Plazmy I Problemy Upravliaemago Termidernogo Sinteza, No. 4, (73A43654), 1973.

(21) Paulus, P. N., "The Electrophoretic Flow Process", National Lending Library for Science and Technology, Boston, SPA (England).

(22) Uloschik, V. S., "The Role of Certain Physicochemical Parameters of Ions in Iontophoretic Permeability of the Living Skin", Institut Nevrologii, Minsk, USSR, (74A1478), Oct.,1973.

(23) Jann, W. K., Jr., "Space Processing Applications - Its Potential Future Impact in the Biologicals Area", NASA/MSFC, December, 1973, 18 pgs.

(24) "Electrophoresis Experiment Analysis in Space", Lehigh University, NASA Contract NAS8-28654, 1974.

Section VII. B.

(25) Bier, M., Snyder, R. S., "Electrophoresis in Space at Zero Gravity", University of Arizona, NASA/MSFC, 12th AIAA Aerospace Sciences Meeting, Washington, D. C., AIAA Paper 74-210)74A18854), Feb. 1, 1974, 6 pgs.

Abstract: Value of space electrophoresis is enhanced by isoelectric focusing and isotochophoresis to increase resolution.

(26) Marshall, D. L., "Sample Detection and Analysis Techniques for Electrophoretic Separation", Battelle Memorial Institute, NASA Contract NAS8-29629, BMI 8-29629-MR-1, May 21, 1974.

(27) Lindberg, R. G., (Panel Chairman), "American Institute of Biological Sciences Panel on Electrophoresis in Space", American Institute of Biological Sciences, Arlington, VA, NASw-1901, Report to NASA/HDQTS, June, 1974, 74 pgs.

Abstract: The study is concerned with the effectiveness of electrophoresis in space compared with similar separation done on the ground and the consideration of what biological materials or biomedical problems will benefit from electrophoresis in space.

(28) Bier, M., Hickley, O. N. Smolka, A. J. K., Snyder, R. S., et al, "Role of Gravity in Preparative Electrophoresis", VA Hospital, Tucson, Arizona, The Proceedings of the Third Space Processing Symposium, Vol. II, M-74-5, June, 1974, pgs. 729-755.

Abstract: Current state of the art of electrophoresis, emphasis on the role of gravity and the possible use of istachophoresis.

(29) Seaman, F.G.F., Allen, R. E., Barlow, G. H., Bier, M., Bigazzi, P. E., "Detailed Results of ASTP Experiment MA-001", Second European Symposium on Materials Sciences in Space, Frascati, Italy, April, 1976.

Abstract: Engineering and operational tests of zone electrophoresis apparatus in low-gravity.

Section VII.B.

(30) Lewis, G., Watt, J. G., "A Preliminary Study of a General Purpose Floating Zone Electrophoresis Facility for Spacelab", British Aircraft Corp., Bristol, United Kingdom, Second European Symposium on Material Sciences in Space, Frascati, Italy, April, 1976.

Abstract: Paper reports recent study of the technical and scientific problems inherent in the design, construction, and operation of a containerless floating zone electrophoresis facility suitable for Spacelab flight.

(31) van Oss, C. J., et. al., "Preparative Electrophoresis of Human Lymphocytes", State University of New York, Buffalo; Preparative Biochemistry 4(5), 457-472, (1974).

(32) Snyder, R. S.; Bier, M., et. al. "Free Fluid Particle Electrophoresis on Apollo 16" Separation and Purification Methods, 2(2), 259-282, (1973).

2. PARTICLE ELECTROPHORESIS

(1) Huebner, V. R., Shacks, S., Stickler, A., "Rapid Free-Film Particle Electrophoresis - A New Clinical Capability", 1967 Annual Scientific Meeting of the Aerospace Medical Association, Washington, D. C., (67A41628), April, 1967.

(2) Snyder, R. S., et. al., "Free Fluid Particle Electrophoresis on Apollo 16", Separation and Purification Methods, Vol. 2, 1973, pgs. 259-282.

3. ELECTROMAGNETOPHORESIS

(1) Kowalczyk, J., Krajewski, R., Pompowski, I., "Electromagnetophoresis of Electrically - Charged Particles", NASA/HDQTS, NASA-TT-F-9504 (65X18996), Aug., 1965.

4. CONTINUOUS FREE FLOW ELECTROPHORESIS

(1) "A Study of Aerosol Particle Fractionation by Continuous Particle Electrophoresis", Beckman Instruments, Fullerton, CA, PR-2424-1 (66X23863), May 31, 1966.

Section VII.B.

(2) Heubner, V. R., "A Study of Aerosol Particle Fractionation by Continuous Particle Electrophoresis", Beckman Instruments, Fullerton, CA, PR-2424-5, Progress Report, (67X23454), Sept., 1967.

(3) "Fluid Flow Electrophoresis In Space", GE, Valley Forge, PA, NASA Contract NAS8-29878, Contractor Report No. GE8-29878-MR-1, March 31, 1974.

(4) Hannig, K., Wirth, H., "Detailed Results of ASTP Experiment MA-014 (Continuous Flow Electrophoresis)", Max-Planck, Institut fur Biochemie, Munchen, Germany, Second European Symposium on Material Sciences in Space, Frascati, Italy, April 1976.

(5) Ostrach, S., "Convection in Continuous - Flow Electrophoresis", Case Western Reserve University, Cleveland, Ohio, Second European Symposium on Material Sciences in Space, Frascati, Italy, April 1976.

Abstract: Various types of convection possible in electrophoresis devices are indicated and criteria are presented from which estimates can be made of the importance of convection in separation.

(6) McCreight, L. R., Griffin, R. N., Locker, R. J., "Continuous Flow Electrophoresis Separator for Biologicals", GE, Valley Forge, PA, Second European Symposium on Material Sciences in Space, Frascati, Italy, April 1976.

Abstract: Thicker separation chamber operations can be performed in low-g than 1-g permitting improved resolution or shorter separation time per unit of sample.

5. GEL ELECTROPHORESIS

(1) Clark, D. A., Mosser, E. L., "Estimation of Serum Proteins by Quantitative Densitometry After Gel Electrophoresis", USAF School of Aerospace Medicine, Brooks AFB, TX, AD-68317 (69N26294), Dec. 1968.

Section VII. B. 6.

6. IMMUNOELECTROPHORESIS

(1) Russel, W. J., "Some Influences of Antigen Concentration and Nonreacting Additives on Mobility and Diffusion in Immunoelectrophoresis", Journal of Immunology, Vol. 95, School of Aerospace Medicine, USAF, Brooks AFB, TX SAM-TR-66-219 (68N87844), Feb., 1966.

(2) Griffin, R. N., McCreight, L. R., "Convectionless Electrophoretic Separation of Biological Preparations", NASA-CR-123920 (73N11055), June 24, 1972.

(3) Bigazzi, P., "Electrophoretic Separation of Cells in Space", NASA Contracts NAS8-29745 and NAS8-31292, 1973.

(4) "Differential Electrophoretic Separation of Cells and Its Effect on Cell Viability", Georgetown University, NASA Contract NAS8-29778, Many, 1973.

(5) Brown, R. K.,"Electrophoretic Separation of Proteins in Space", Wayne State University, NASA Contract NAS8-29823, September 15, 1973, 55 pgs.

Abstract: Commercially available and synthetic wide range and short range ampholytes used in the isoelectric focusing of proteins can be analyzed by ion exchange chromotography.

(6) van Oss, C. J., Bigazzi, P. E., Gillman, C. F., Allen, R., "Preparation Liquid Column Electrophoresis of T and B Lymphocytes at Gravity = 1", State University of NY at Buffalo, NASA/MSFC, 12th AIAA Aerospace Sciences Meeting", AIAA Paper 74-211 (74A18863), Feb., 1974, 4 pgs.

Abstract: Vertical liquid columns with density gradients to simulate zero gravity, and upward electrophoresis in vertical columns are hampered by convection and sedimentation problems which can be eliminated by a zero gravity environment.

(7) Knox, R. J., "Electrophoretic Characterization of Aldehyde-fixed Red Blood Cells, Kidney Cells, Lymphocytes and Chamber Coatings", University of Oregon Health Sciences Center, Portland, Oregon, NASA Contract NAS8-30887, Final Report, December 31, 1975, 43 pgs.

Abstract: Work associated with pre-flight and post-flight analyses of ASTP experiment MA011.

(8) Bier, M., Criddeback, R. M., Kopwillem, A., "The Role of Gravity in Preparative Electrophoresis", VA Hospital, University of Arizona, Tucson, Arizona, Journal of Chromatography, March 3, 1976.

Abstract: Preparative Plasma Protein Fractionation by Isotachophoresis in Sephadox Columns.

(9) Liehener, D., "Immological Aspects in Space Experiments", Max-Planck-Institut fur Biochemie, Muchen, Germany, Second European Symposium on Material Sciences in Space, Frascati, Italy, April, 1976.

Abstract: A promising experiment in this direction would be to perform suspend cell cultures to study the mechanism of T- and B- cell cooperation under better defined conditions.

7. DISC ELECTROPHORESIS

(1) Rendon, L., "Electrophoretic Separations of Acrylamide Gels - Disc Electrophoresis", Aerospace Medical Research Labs, Wright-Patterson AFB, Ohio, AMRL-TR-65-202 (66N39798), December, 1965.

8. PAPER ELECTROPHORESIS

(1) Lingren, W. E., Marson, R., Reeck, G., "The Paper Electrophoresis of the Iron/II - Iron/III/System", Naval Radiological Definse Lab., San Francisco, Cal., USNRDL - TRC - 84 (67N19618), Sept., 1966.

Section VII. B. 8.

(2) Frahn, J. L., "Paper Electrophoresis of Pyrrolizidine Alkaloids", Australian Journal of Chemistry, Vol. 22, (70N70722), August, 1969.

9. CONTROL METHODS

(1) Krupnick, A. C., "Development of Coatings to Control Electroosmosis in Zero Gravity Electrophoresis", 12th AIAA Aerospace Sciences Meeting, Washington, D. C., AIAA Paper 74-157 (74A18844), January, 1974.

Abstract: Gamma amino propyl trihydroxysilane provides low potential coating (-3.86 mv.) as surface of shear between mobile and stationary layers to control electrokinetic effects.

(2) Andrade, J. D., Lentz, D. J., "Preparation and Investigation of Methacrylate Hydrogels for Zeta Potential Control", University of Utah, Salt Lake City, Utah, NASA Contract NAS8-30253, June, 1975, 41 pgs.

Abstract: Measurement technique developed to evaluate the effects of hydrophilic coatings on electroosmatic flow.

10. ELECTROPHORETIC EQUIPMENT

(1) Shaw, R. K., "Preparative Electrophoresis Equipment for Laboratory Use", Suffield Experiment Station, Ralston, Alberta, SUFFIELD-TP-204, (65N21717), April, 1964.

(2) "Preliminary Design, with Design Parameters of a Miniaturized Microbiology Laboratory", Fiarchild-Hiller Corp., Farmingdale, N. Y., NASA Contract NAS8-26551, Jan., 1971.

(3) Thiehler, A., "Preparative Electrophoresis Experiment Design", Beckman Instruments, Fullerton, Cal., NASA Contract NAS8-28474, Final Report, NASA-CR-123972 (73N14090), Oct., 1972, 26 pgs.

Section VII. B. 10.

Abstract: Critical review of electrophoresis, study of new techniques for enhancing resolution and stability, and construction and testing of a high resolution cell.

(4) Veen, G. E., "Electrophoretic Separator Project M570", GE, Valley Forge, PA, NASA Contract NAS8-28365, Final Report Oct., 1972.

(5) Reddick, J. M., Hirsch, I., "Design Modification of Electrophoretic Equipment", Federal City College, Washington, D. C., 73N21140, Feb., 1973.

(6) Barlow, G., "Electrophoresis Experiment", Abbott Labs, NASA Contract NAS8-30591, 1974.

(7) Marshall, D. L., "Sample Detection and Analysis Techniques for Electrophoretic Separation", Battele Institute, Cleveland, Ohio, NASA Contract NAS8-29629, BMI-8-29629-MR-1, May, 1974.

(8) "Electrophoretic Separator for Purifying Biologicals", GE, Valley Forge, PA, NASA Contract NAS8-31036, Sept., 1975, 28 pgs.

Abstract: Three major task of this contract are Task I- Design Criteria Optimization - Math Modeling; Task II - Design, Build, and Test a flowing electrophoretic Separator System, and Task III- Experimental operations of the system.

11. APPLICATIONS

(1) Preetz, W., "Separation, Isolation, and Investigation of Mixed Liganel Complex of Platinum Elements with the Help of High Voltage Electrophoresis", Technische University, Berlin, Germany, (70N77103), 1963.

Section VII. B. 11.

(2) L. D., "Mechanical Effects of AC Fields on Particles Dispersed in a Liquid, Biological Implications", Pennsylvania University, Philadelphia, PA, (70N73449), 1963.

(3) Thornhill, J. W., "Material Processing and Phenomena Investigations for Functional Electronic Blocks", Westinghouse, Pittsburgh, PA, (66N13463), 1965.

(4) Hurwitz, M., Lubin, B. T., "Research and Design of a Practical and Economical Dielectrophoretic System for the Control of Liquid Fuels Under Low Gravity Environmental Conditions", Dynatech Corp., Cambridge, Mass., Contract NAS8-20553, NASA-CR-91144PR-3 (68X80371), March, 1966.

(5) Heemstra, R. J., Johansen, R. T., "The Application of an Improved Continuous Electrophoresis Apparatus to the Study of Petroleum", Bureau of Mines, Bartlesville, Okla., BM-RI-6912 (67N26309), 1967.

(6) Kleiner, H., Schram, E., "Separation of Isozymes Hydrolyzing L - Leucyl - Beta - Napthylamide by Vertical Electrophoresis in Acrylamide Gel, NASA/HDQTS, NASA-TT-F- 10724 (67X12331), Feb., 1967.

(7) Vacca, G., Trovati, C., "Relation Between Lactic Dehydrogenase and Alpha - Hydroxybutyric Dehydrogenase of the Red and White Blood Cells", Techtran Corp. Glen Burnie, Maryland, NASA-TT-F-13990 (72N12016), December, 1971

(8) Sagone, I., "Micro-electrophoresis of Human Erythrocytes - Importance and Uses in Obstectrics and Gynecology", Translation Consultants, Arlington, VA, NASA-TT-F-14587 (73N13077), Dec., 1972.

(9) "Feasibility Study for the Manufacture of Pharmaceuticals, Immunoligical and Viral Agents", Arthur D. Little, Inc., NASA Contract NAS8-29874, Contractor No. LITTLE 8-29874-MR-Sept. 73, Sept., 1973.

(10) van Oss, C. J., Bigazzi, P. E., Gilman, C. F., Allen, R. E., "Parpartive Electrophoresis of Living Lymporhytes, The Proceedings of the Third Space Processing Symposium, Vol. II, M-74-5, June, 1974, pgs. 755-763.

Abstract: Due to convection and sedimentation, separation at 1g is less than ideal, but it is expected that at 0 gravity electrophoresis will prove to be a uniquely powerful cell separation tool.

(11) Bier, M., "Potential Contribution of the Space Program to the Advancement of Electrophoresis and Its Biomedical Applications", VA Hospital, Tuscon, Arizona, Paper Submitted to the Subcommittee on Space Science and Applications, U. S. House of Representatives, July 14, 1975, 17 pgs.

Abstract: Electrophoretic techniques are limited in achieving its fullest potential by gravity effects. A zero-gravity facility on Shuttle will provide new impetus to both our cell biology research and its applications to diverse problems in medicine.

(12) Hannig, K., Schindler, R., "Overview Electrophoresis Experiments on ASTP", MAX-Planck-Institut fur Biochemie, Muchen, Germany, Second European Symposium on Material Sciences in Space, Frascati, Italy, April, 1976.

Abstract: Review of MA011 and MA014 ASTP electrophoresis experiments.

12. DIELECTROPHORESIS

(1) Fiks, V. B., "Electrophoresis of Dielectric Particles in Liquid Metals and Semiconductors", Fizika Metallov I. Metallovendeme, Vol. 18, (65A15722), Nov., 1964.

(2) Fahiman, E. J., Hurivitz, M., Melcher, J. R., "Research and Design of a Practical and Economic Dielectriphoretic System for the Control of Liquid Fuels Under Low Gravity Environmental Conditions, Dynatech, Corp., Cambridge, Mass., NASA-CR-88728 (67X88811), 1966.

Section VII. B. 12.

(3) Oker, E., Merte, H., Jr., "Transient Boeing Heat Transfer in Saturated Liquid Nitrogen and F113 at Standard and Zero Gravity", NASA-CR-120202 (74N21585), Oct., 1966.

Abstract: Transient and steady state nucleate boiling for heating surface horizontal up, vertical and horizontal down orientations, observing conduction and convection regimes.

(4) Blutt, J. R., "Operating Safety of Dielectrophoretic Propellant Management Systems", Dynatech Corp., Cambridge, Mass., NASA-CR-101422 (69N28118), March 31, 1968, 55 pgs.

Abstract: Small and full scale electrode systems experiments indicate full scale performance predictibility from small scale breakdown tests. Aluminum and stainless steel electrodes with Teflon supports were compatible with oxygen and hydrogen.

(5) Mesnard, G., Stenghal, B., "Semiconducting and Dielectric Properties of Sintered Electrophoretic Layers of Barium Titante Doped with Samarium or Lanthanum, Sciences Physics, Vol. 267, (68A36299), July, 1968.

(6) Kirko, I. M., Kuznetsova, T. V., Mikhailov, N. D., "Observation of Dielectrophoresis Under the Conditions of Weightlessness", Soviet Physics Reports, Vol. 16, (72A14988), Dec., 1971, 2 pgs.

Abstract: English translation.

13. CHROMATOGRAPHY

(1) Verly, W., "Preparation and Purification of Toritiated Geranyllinolol", Liege University, Belgium, (66N13590), 1965.

(2) Li, H. Y., Yeh, K. H., Yuan, C. Y., "Studies on Organophosphorus Compounds - Deparation of Alkylphosphoric Acids by Paper Electrophoresis and Paper Chromatography", Joint Publications Research Service, Translation on Communist China Science and Technology, Vol. 25, (65N32602), Aug., 1965.

(3) Massaglia, A., Rosa, U., "Separation of the I-131 Labelled S - Sulphonated A and B Insulin Chains by Thin-Layer Chromatography", Societa Ricerche Impianti Nucleari, Saluggia, Italy, SORIN-65 (69N77736), 1965.

(4) Oyoshi, A., Oyoshi, E., Sinagawa, M., "Studies on Focusing Chromatography Separation of Neptunium - 239 From Neutron-Irradiated Uranium", Osaka University of Japan, (66N37884), Oct., 1965.

(5) Clanet, F., "Study of CiS and Trans Uranium Elements By Paper Chromatography and Electrophoresis", Commissariat A L'Energie Atomique, Fontenay - Aux - Roses, France, CEA-R-3411 (68N35651), 1968.

(6) Alberti, G., Allulli, S., "Chromotography and Electrophoresis of Inorganic Ions in Fused Salts", Comitato Nazionale Per L'Energia Nucleare, Rome, Italy, (69N75305), 1968.

14. ISOTACHOPHORESIS

(1) Bier, M., Hinckley, J.O.N., Smolka, A.J.K., "Potential Use of Isotachophoresis in Space - Protides Biological Fluids", 22nd Colloquium, Pergamon Press, N. Y., 1975, pgs. 673-678.

(2) Smolka, A. J. K., Bier, M., "Isotachophoresis of Living Cells", FASEB, 1975.

C. GENERAL CHEMICAL PROCESS STUDIES

(1) Cook, G. M. W., Heand, D. H., Seaman, G. V. F., "Sialic Acids and the Electrokinetic Charge of the Human Enthrocyte", Nature, Vol. 191, 1961, pgs. 44-47.

(2) Shapiro, N., "Analysis of Migration in the Presence of Chemical Reaction", Rand Corp. Santa Monica, Cal., P-2596 (65N30646), June, 1962.

(3) Ensanian, M., "The Influence of Gravitational Variations on the Rates of Chemical Processes", Bell Aerospace, Buffalo, N. Y., 4th Canaveral Council of Technical Societies, Space Congress on the Challenge of the 1970's,

Abstract: Quadrant Mechanical Hypothesis (QMH) on gravitation, gravitational chemistry and effects of zero gravity on various chemical processes. Some key words: chemical kinetics, diffusion, reaction theory.

(4) Butner, S., Fogarty, J., "Chemical Reaction in Low and Zero Gravity - A Feasibility Study", Grumman Aerospace Corp. Bethpage, N. Y., (70N20546), Feb., 1970.

Abstract: Effects of reduced gravity and weightlessness on fluidized bed polymerization reaction.

(5) Weunscher, H. F., "Method of Making Foamed Materials in Zero Gravity", NASA/MSFC, NASA-XMF-09902 (N72-11387), July, 1971, 4 pgs.

Abstract: Method of manufacturing homogeneous foamed materials in weightless environment from constituents having different physical properties.

(6) Seaman, G. V., F., "Electrokinetic Behavior of Red Blood Cells", The Red Blood Cell, Vol. II, Academic Press, N. Y., 1975, pgs. 1135-1229.

D. GENERAL BIOCHEMICAL PROCESS STUDIES

(1) "Analytical Biochemistry", Oak Ridge National Labs, Tennessee, (69N38858), Dec., 1968.

(2) Tiselius, A., "Development of Separation Methods Applied to Biochemical Materials", Royal Swedish Academy of Engineering Sciences, Stockholm, Sweden, (71N24466), 1970.

(3) Jordan, R. T., "Industrial Microbiological Applications in Zero Gravity - A Vaccine Satellite Program", MMA, Denver, Colorado, (70N20529), Feb., 1970, 14 pgs.

(4) "Preliminary Design, with Design Parameters of a Minaturized Microbiology Laboratory", Fairchild-Hiller, Contract NAS8-26552, Jan., 1971.

(5) Kober, C. L., "Chemical and Biochemical Space Manufacturing", MMA, Denver, Colorado, (71N26013), April, 1970, 10 pgs.

Abstract: Use of scaling laws and Gibbs phenomenon in weightless chemical and biochemical manufacturing.

(6) Foster, J. F., Certain, A. J., "Study on Biogrowth Processing in Space", Battelle Institute, Columbus, Ohio, Contract NAS8-28085, BMI, 8-28085-MPR-1, May, 1972.

(7) Griffin, R. N., McCreight, L. R., "Convectionless Electrophoretic Separation of Biological Preparations', GE, Valley Forge, PA, NASA Contract NAS8-27797, NASA-CR-123920 (73N11055), June, 1972.

(8) Jordan, R. T., "Earth Orbital Systems and Biochemical Research", Charles E. Dettering Research Labs., Yellow Springs, Ohio (A74-14109), Dec., 1972, 32 pgs.

Abstract: Some key words: Biological effects, dialysis, fermentation, metabolic wastes, microorganisms; buoyancy, reduced gravity; liquid-gas mixtures; space shuttle.

Section VII. D.

(9) Hanning, K., "Techniques of Biochemical and Biophysical Morphology", Vol. I, 1974.

APPENDIX A

SUBJECT INDEX

SUBJECT INDEX

APPENDIX B

CONTRACT INDEX

Contract Index

By Subject

I. General Space Manufacturing

A. Survey Papers
Contracts: 8-24979 General Dynamics, Convair

B. Facilities
Contracts: 8-20582 Astro-Space Labs, Inc.
8-20707 Astro-Space Labs, Inc.
8-21279 Martin Marietta Corp.
8-26122 Westinghouse
8-27718 Hewlet-Packard
8-28055 Massachusetts Institute of Technology
8-28059 Weiner Associates
8-28271 Westinghouse
8-28729 Lockheed Missiles and Space Company
8-29769 Antcor Inc.
8-28960 Lockheed Missile and Space Company
8-29860 Georgia Institute of Technology
8-30036 Astro-Space Labs, Inc.
8-30268 Lockheed Missile and Space Company
8-30289 Westinghouse
8-30166 Astro-Space Labs, Inc.
8-30528 Astro-Space Labs, Inc.
8-30741 Bendix Corporation

C. General Application Papers
Contracts: 8-29748 Battelle Memorial Institute
8-25202 Carnegie-Mellon University
8-28615 General Dynamics, Convair
8-28179 General Electric Company, Space Science Div.
8-29874 Arthur D. Little, Inc.
8-29669 United Aircraft Corp., Pratt and Whitney
8-29881 Auburn University
8-27942 General Electric
8-31533 McDonnell Douglas Astronautics Co.
8-21279 Martin Marietta Corp.
8-28938 TRW System Group
8-24633 General Electric Corp.
8-24979 General Electric Corp.
8-27734 Universities Space Research Association

II. Space Manufacturing Management and Planning

A. General Planning

Contracts: 8-21804 Teledyne-Brown Engineering Co.
8-27734 Universities Space Research Association
8-28359 URS/MATRIX Co., Man Systems Div.
8-28730 Westinghouse Electric Corporation

B. Skylab Program Planning
Contracts: 8-28730 Westinghouse Electric Corp.

C. Sounding Rocket Planning
Contracts: 8-30528 Astro-Space Labs, Inc.

D. Space Shuttle Planning and Utilization
Contracts: 8-28583 McDonnell Douglas Astronautics Co.
10-8606 TRW Systems Group

E. Space Shuttle Design/Payload Interface
Contracts: 8-29462 General Dynamics, Convair
8-28960 Lockheed Missiles and Space Co.
8-28938 TRW Systems Group, Redondo Beach
8-29359 URS/Matrix Co.
8-31444 TRW Systems Group

III. Fluid Mechanics and Heat Transfer

A. General Fluid Motion Studies
Contracts: 8-21012 Electro-Optical Systems, Inc.
8-20146 General Dynamics, Convair
8-25179 Georgia Institute of Technology
8-28644 Boeing
8-27015 Lockheed Missile and Space Co.

B. General Heat Transfer Studies
Contracts: 8-21143 University of Alabama - Tuscaloosa
8-25577 Lockheed Missile and Space Co.

C. Convection Studies
Contracts: 8-25577 Lockheed Missiles and Space Co.
8-27015 Lockheed Missiles and Space Co.
8-29710 Lockheed Missiles and Space Co.
8-28732 Massachusetts Institute of Technology

C. Liquid Floating Zone
Contracts: 8-29877 Arthur D. Little, Inc.
8-27015 Lockheed Missiles and Space Co.

E. Application Studies
Contracts: 8-30250 Colorado State University

IV. Solidification Processes

A. Solidification on Studies

Contracts: 8-24592 Cornell Aeronautical Laboratory
8-27891 Grumman Aerospace Corp.
8-28308 Texas Instruments
8-28056 Grumman Aerospace Corp.
8-28604 Grumman Aerospace Corp.
8-28664 Boeing Aerospace Company, Huntsville
8-28723 Arthur D. Little, Inc.
8-28724 United Aircraft Corp., Pratt and Whitney
8-28725 Battelle Memorial Institute
8-28728 Grumman Aerospace Corp.
8-28729 Lockheed Missiles and Space Co.
8-28732 Massachusetts Institute of Technology
8-28733 University of Wisconsin
8-28734 University of Connecticut
8-28734 Georgia Institute of Technology
8-28749 Battelle Memorial Institute
8-28730 Westinghouse Electric Corp.
8-29145 Arthur D. Little, Inc.
8-29626 Battelle Memorial Institute
8-29650 University of Alabama, Huntsville
8-29662 Grumman Aerospace Corp.
8-29851 Texas A&M University
8-29854 University of California, Los Angeles
8-29877 Arthur D. Little, Inc.
8-29951 Brown Engineering Company
8-31350 Massachusetts Institute of Technology
8-31384 Battelle - Northwest
8-21123 Lockheed Missiles and Space Co.
8-30561 Athens College
8-31529 Grumman Aerospace Corp.

B. Immiscibles

Contracts: 8-27085 TRW Systems Group
8-28267 TRW Systems Group
8-28309 TRW Systems Group
8-29748 Battelle Memorial Institute
8-27809 University of Alabama
8-29725 Washington State University

C. Composite Casting Studies

Contracts: 8-21402 Arthur D. Little, Inc.
8-25709 Arthur D. Little, Inc.
8-26402 University of California, Los Angeles

C. Composite Casting Studies (Cont'd)

Contracts: 8-26991 University of Alabama, Huntsville
8-27106 Cornell Aeronautical Laboratory
8-27806 General Dynamics, Convair
8-28189 Massachusetts Institute of Technology
8-28735 Georgia Institute of Technology
8-29620 General Dynamics, Convair
8-24979 Grumman Aerospace Corp.
8-27085 TRW Systems Group
8-28724 United Aircraft Corp.
8-29629 Battelle Memorial Institute
8-29854 University of California at Los Angeles
8-31534 Marvaland, Inc.

D. Crystal Growth

Contracts: 8-29847 University of Southern California
8-30576 Massachusetts Institute of Technology
8-28306 Massachusetts Institute of Technology
8-24683 General Electric Corp.
8-24509 Westinghouse Electric Corp.
1-11869 Southern Methodist University
8-27807 Texas Instruments, Inc.
8-28305 University of Southern California
8-31530 Grumman Aerospace Crop.
8-26122 Westinghouse
8-28098 University of Alabama at Huntsville
8-29077 Eagle-Pitcher, Inc.
8-29875 Battelle Memorial Institute
8-28189 Massachusetts Institute of Technology
8-28304 University of Alabama at Huntsville
8-26146 Rensselaer Polytechnic Institute
8-30578 Rensselaer Polytechnic Institute
8-29494 University of Alabama at Huntsville
8-30171 PEC Research Associates
8-29542 University of Alabama at Huntsville
8-29650 University of Alabama at Huntsville
8-30744 University of Alabama at Huntsville
8-26122 Westinghouse Research Laboratories
8-24612 University of Alabama at Huntsville
8-27942 General Electric Co., Space Science Lab.
8-25120 University of Alabama at Huntsville
8-26158 Westinghouse Research Laboratories
8-28112 University of Alabama, Huntsville
8-28114 General Electric Company, Space Div.
8-26793 University of Alabama, Huntsville
8-28725 Battelle Memorial Institute
8-30537 Massachusetts Institute of Technology

V. Containerless Processing

A. General Studies
Contracts: 8-26157 General Electric Co., Space Sciences Lab.
8-30250 Colorado State University
8-28729 Lockheed Missiles and Space Co.

B. Position Control Techniques
Contracts: 8-28762 Interand Corp.
8-29030 Interand Corp.
8-30471 Intersonics, Inc.
8-27228 General Electric Company, Space Science Div.
8-29680 General Electric Company, Space Sciences Lab.

C. Heating and Cooling Techniques
Contracts: 8-29860 Georgia Institute of Technology
8-30268 Lockheed Missiles and Space Co.
8-25364 Massachusetts Institute of Technology
8-24365 Massachusetts Institute of Technology
8-21347 Lockheed Missiles and Space Co.
8-28059 Weiner Associates, Inc.
8-29769 Artcor Corp.
8-30289 Westinghouse Research Laboratories

D. Application Studies
Contracts: 8-26157 General Electric Company
8-29879 General Electric Company
8-29860 General Electric Company

VI. Glass and Ceramic Material Processing

A. General Studies
Contracts: 8-28014 North American Rockwell
8-28991 Rockwell International Corp.
8-30627 ITT Research Institute
8-30656 Vanderbilt University
8-29850 ITT Research Institute
8-29626 Battelle Memorial Institute

B. Methods of Preparation Studies
Contracts: 8-29850 ITT Research Institute

VII. Electrophoretic, Chemical and Biochemical Processes

A. General Separation Studies
Contracts: 8-29609 Lockheed Missiles and Space Co.
8-29629 Battelle Memorial Institute
8-30252 Howard University

B. Electrophoretic Methods

Contracts: 8-28654 Lehigh University
8-29878 General Electric Co., Space Sciences Lab.
8-24683 General Electric Company
8-28474 Beckman Instruments, Inc.
8-29566 University of Arizona
8-29629 Battelle Memorial Institute
8-29745 State University of New York, Buffalo
8-29778 Georgetown University
8-29823 Wayne State University
8-30887 University of Oregon
8-30253 University of Utah
8-296551 Fairchild Hiller, Inc.
8-28365 General Electric Company
8-30591 Abbott Labs
8-29874 Arthur D. Little
8-20229 University of Michigan
8-20553 Dynatech Corp.

C. General Chemical Process Studies

D. General Biochemical Process Studies

Contracts: 8-26552 Fairchild Hiller Corporation
8-27797 General Electric Company, Space
8-28085 Battelle Memorial Institute
8-28411 Massachusetts Institute of Technology

APPENDIX C

AUTHOR INDEX

AUTHOR INDEX

AUTHOR INDEX (CONT'D)

AUTHOR INDEX (CONT'D)

AUTHOR INDEX (CONT'D)

AUTHOR INDEX (CONT'D)

AUTHOR INDEX (CONT'D)

APPENDIX D

CORPORATE INDEX

CORPORATE INDEX

CORPORATE INDEX (CONT'D)

CONTRACTOR	CONTRACT NO.	PRINCIPAL INVESTIGATOR	PRINCIPAL AUTHOR
Auburn Univ. Auburn, AL	NAS8-29881 NSR-1-003-025		
Battelle Memorial Institute Columbus, Ohio	NAS8-28085 NAS8-28725	Cutain,Schneider	Foster;Cutain Pattee;Rothman Monroe
	NAS8-28749	N. M. Griesenauer	N. M. Griesenaur
	NAS8-29626	S. H. Gelles	S. H. Gelles
	NAS8-29629		D. L. Marshall
	NAS8-29748	S. H. Gelles	
	NAS8-29867	N. M. Griesenauer J. F. Miller	Griesenauer; Miller
	NAS8-31445		
Bechman Instruments, Inc. Anaheim, CA	NAS8-28474		A. Theiehler
Bendix Corp.	NAS8-30889		
Brown Engr. Co. Huntsville, AL	NAS8-29951		
Boeing Aero. Co. Huntsville, AL	NAS8-28664	Henderson	
Univ. of Cal. at Los Angeles Los Angeles, CA	NAS8-26402 NAS8-28310 NAS8-29854	A. S. Yue A. S. Yue A. S. Yue	A. S. Yue
Carnegie-Mellon Univ. Pittsburgh, PA	NAS8-25202 NAS8-25203		
Colorado State Univ.	NAS8-30250	Winder	T. B. Jones
Univ. of Conn. Inst. of Materials Science Storrs, Conn.	NAS8-28734	T. Z. Kattamis	T. Z. Kattamis

CORPORATE INDEX (CONT'D)

CONTRACTOR	CONTRACT NO.	PRINCIPAL INVESTIGATOR	PRINCIPAL AUTHOR
Cornell Aero. Lab. Buffalo, N.Y.	NAS8-24592	T. J. Fabiniak	T. J. Fabinial Abbot et al
	NAS8-27106		R. C. Fabiniak et al
H. E. Cramer Co. Inc. Salt Lake City, Utah	NAS8-29033		
Dynatech Corp. Cambridge, Mass.	NAS8-20553		Fahimian;Hurwitz Blutt et al
Eagle-Picher Indust., Inc. Miami, Oklahoma	NAS8-29077	Doty, Reising	Doty;Reising
Electro-Optical Systems, Inc.	NAS8-21012		
Fairchild-Hiller Corp.	NAS8-26552		
General Dynamics Convair Division San Diego, CA	NAS8-20146		Hudson, et al
	NAS8-24952		
	NAS8-24979	Gorham;Steurer	Gorham;Steurer
	NAS8-25051		
	NAS8-27806	Steurer	Steurer;Kaye
	NAS8-28056	Steurer;Wood	
	NAS8-28615	Steurer	Steurer;Kaye Gorham
	NAS8-29462		
	NAS8-29620	Steurer;Kaye	
General Electric Co., Space Science Lab. (Space Science Div.) Philadelphia, PA	NAS8-24683		R. N. Griffin, et al
	NAS8-26157	R. T. Frost	R. T. Frost, et al
	NAS8-27228	R. T. Frost	M. F. Clark Beurger, et al
	NAS8-27797	L. R. McCreight	Griffin;McCreight
	NAS8-27942		Ulrich;McCreight
	NAS8-28114	D. R. Ulrich	Ulrich, et al

CORPORATE INDEX (CONT'D)

CONTRACTOR	CONTRACT NO.	PRINCIPAL INVESTIGATOR	PRINCIPAL AUTHOR
General Electric (Cont'd)	NAS8-28179 NAS8-29680 NAS8-29878 NAS8-29879 NAS8-30797 NAS8-31152 NAS8-31036	H. L. Bloom R. T. Frost	Scarff; Bloom R. T. Frost, et al
Georgetown Univ.	NAS8-29778	E. M. Leise	
Grumman Aerospace Corp.	NAS8-27891	C. Li	C. Li; Mukherjee; et al
Bethpage, N.Y.	NAS8-28604 NAS8-28728 NAS8-29662	D. Larson C. Li	W. M. Aubin, et al Larson; Li; Busch
Georgia Inst. of Tech. Atlanta, GA	-25179 NAS8-28735 NAS8-29860	H. F. Bauer J. L. Brown R. K. Hart	Brown; Johnson; Hubbard
Hetherington, JS Menlo Park, Ca.	NAS8-31417		
Hewlet-Packard	NAS8-27718		
Howard Univ. Washington, D. C.	NAS8-30252	A. D. Ukanwa	
Interand Corp. Chicago, Ill.	NAS8-28762 NAS8-29030	R. R. Whymark R. R. Whymark	R. R. Whymark R. R. Whymark
Intersonics, Inc. Chicago, Ill.	NAS8-30471 NAS8-32106	R. R. Whymark	R. R. Whymark
ITT Res. Inst. Chicago, Ill.	NAS8-29850 NAS8-39627	D. C. Larsen D. C. Larsen	D. C. Larsen Larsen; Crandall
Jet Propulsion Lab Pasadena, CA	NAS7-100	T. Wang	
Lehigh Univ. Bethlehem, PA	NAS8-28654		

CORPORATE INDEX (CONT'D)

CONTRACTOR	CONTRACT NO.	PRINCIPAL INVESTIGATOR	PRINCIPAL AUTHOR
Arthur D. Little, Inc.	NAS8-21402		J. Berkowitz-Mattuck et al
Cambridge, Mass.	NAS8-25709		
	NAS8-26637		
	NAS8-28723		Johnson; Peters
	NAS8-29145	P. C. Johnson	P. C. Johnson
	NAS8-29874		
	NAS8-39877		Fowle; Haggerty
Lockheed Missiles and Space Co.	NAS8-21123	P. G. Grodzka	P. G. Grodzka
	NAS8-2.347	V. W. Sparks	V. W. Sparks
Huntsville, AL	NAS8-25577	Fan; Grodzka	Fan; Grodzka; Benefield, et al
	NAS8-27015	C. Fan	Bourgeois; Fan; Grodzka; et al
	NAS8-28170		
	NAS8-28729		M. R. Brashears, et al
	NAS8-29609	P. G Grodzka	
	NAS8-29610	S. V. Bourgeois	
	NAS8-39268	McDermit	
Lockheed Missiles and Space Co. Sunnyvale, CA	NAS8-28960		
Martin Marietta Corp. Denver, Colorado	NAS8-21279		W. Faber et al
M.I.T.	NAS8-24364	K. Masubuchi	K. Masubuchi
Cambridge, Mass.	NAS8-24365	K. Masubuchi	J. B. Andrews et al
	NAS8-28055	Sheridan, Whitney	Whitney; Iemenschut; Book; Mackro
	NAS8-28189	H. C. Gatos	Gatos; Witt
	NAS8-28411		
	NAS8-28732	K. Masubuchi	Masubuchi; Mur ki; Spearman
	NAS8-30537	Gatos; Witt	
	NGR-22-009-517		
McDonnell Douglas Astronautics Co. Huntington Beach, CA	NAS8-28583		

CORPORATE INDEX (CONT'D)

CONTRACTOR	CONTRACT NO.	PRINCIPAL INVESTIGATOR	PRINCIPAL AUTHOR
National Bureau of Standards	H-84832A W-13475	Kuriyama Passaglia	
National Research Corp.	NAS8-27877		
Univ. of Michigan Dept. of Mich. Engr. Ann Arbor, Mich.	NAS8-20228		Fahimian;Oker; Merke; et al
State Univ. of New York Buffalo, N.Y.	NAS8-29745	P. E. Bigazzi	C. J. van Oss et al
North American Rockwell Corp. Downey, CA SEE ALSO Rockwell International Corp. Downey, CA	NAS8-28014	R. A. Happe	Happe; Topol
Univ. of Oregon	NAS8-30887 NAS8-31386		
Owens-Illinois	NAS8-31381		
P.E.C. Res.Assoc. Inc. Louisville, Col.	NAS8-30171		D. G. Burkhard et al
Raff Assoc.	NAS2-5073	Johnson	
Rensselaer Polytechnic Inst. Troy, N.Y.	NAS8-26146	H. Wiedemeier	H. Weidemeier
Rockwell International Corp. SEE ALSO North American Rockwell Corp.	NAS8-28991	R. A. Happe	R. A. Happe

CONTRACTOR	CONTRACT NO.	PRINCIPAL INVESTIGATOR	PRINCIPAL AUTHOR
Rogosin Kidney Center Cornell Medical Center New York, N.Y.	NAS8-31513		
Univ. of Southern Cal. Chemical Engr. Dept. Los Angeles, CA	NAS8-29847	W. R. Wilcox	W. R. Wilcox
Southern Methodist University	NAS1-11869	Chu	
Teledyne-Brown Engr. Co. Huntsville, AL	NAS8-21804 NAS8-29951		Meyers; Thomas
Texas A&M Univ. College Station, TX	NAS8-29851		
Texas Instruments Inc. Dallas, TX	NAS8-26403 NAS8-27807	Enspruch	F. A. Padovani F. W. Voltmer
TRW Systems Group Redondo Beach, CA	NAS8-27085 NAS8-28267 NAS8-28309 NAS8-28938	J. L. Reger J. L. Reger R. L. Hammel	Reger; Yates Reger; Yates Hammel; Smith Anderson; Bird Waltz
United Aircraft Corp. Pratt & Whitney East Hartford, Conn.	NAS8-28724 NAS8-29669		Douglas; Galasso George
Universities Space Res. Assoc. Charlottesville, VA	NAS8-27734 NGR47-102-003 NAS8-31349	" Leidheiser H. Leidheiser H. Leidheiser	A. R. Kuhlthau

CONTRACTOR	CONTRACT NO.	PRINCIPAL INVESTIGATOR	PRINCIPAL AUTHOR
URS/Matrix Co. Man Systems Div.	NAS8-28359		R. G. Hatterick
University of Utah	NAS8-30253		
Vanderbilt Univ. Knoxville, TN	NAS8-30656	Kinser	
Washington State Univ. Pullman, Wash.	NAS8-29725	Johnson	
Wayne State Univ. Detroit, Mich.	NAS8-29823	R. K. Brown	R. K. Broan
Weiner Assoc., Inc.	NAS8-28050	Eiss, Dussan	
Cockeysville, MD	NAS8-28059	Shadis, Frank	A. Eiss et al
Westinghouse	NAS8-24509		C. S. Duncan et al
Electric Corp.	NAS8-26122	Seidensticker;	Seidensticker;
Westinghouse Res.		Duncan; Johnson	Duncan et al
Labs.	NAS8-26158	Duncan;	Dunacn;
		Rubenstein	Rubenstein
Pittsburgh, PA	NAS8-28271	R. G. Seidenst ..er	
	NAS8-28730		Tobin; Kosscwsky
	NAS8-30289		Mazelsky; Duncan
Univ. of Wisconsin	NAS8-28733	C. M. Adams	
Wyle Labs.	NAS8-39747		

INSTRUCTIONS FOR ORDERING DOCUMENTS

Most documents may be ordered from the National Technical Information Service. These documents are generally indicated by an "N" appearing in the access number (e.g., N76-23074 is the NTIS number assigned to Apollo-Soyuz Test Project: Preliminary Science Report). Inquiries should be addressed to:

National Technical Information Service
Springfield, Virginia 22161

AIAA symposia and journal articles (indicated by an "A" in the access numbers) may be ordered from:

American Institute of Aeronautics and Astronautics
Technical Information Service
750 Third Ave.
New York, N. Y. 10017

Monthly progress reports, working papers, and lab and office memos generally are not available from either of the above sources. Written inquiries concerning such documents should be addressed to the:

Space Processing Applications Project Office/PF11
Marshall Space Flight Center, AL 35812

NOTE: When ordering Proceedings of the Third Space Processing Symposium: Skylab Results (Vols. I and II), requests should be addressed to NTIS, and the following access numbers should be used:

74N29885 (for Vol. I)
74N29905 (for Vol. II)

NOTE: Prices for documents vary. For information concerning charges, contact supplying source.

ADDENDUM

CONTINUED BIBLIOGRAPHY TO JANUARY 1978.

CONTINUED BIBLIOGRAPHY OF MATERIALS PROCESSING IN SPACE

A. BOUND VOLUMES

1. "Proceedings Third Space Processing Symposium Skylab Results Volume I & II," NASA M-74-5, 1974

2. "ASTP - Composite of MSFC Final Science Report," NASA TM-X 73360, 1975.

3. "Space Processing Applications Bibliography," 1976

4. "SPAR I Final Report," NASA TMX-3458, 1976

5. "Material Science in Space," European Space Agency 114, 1976

6. "SPAR II Final Report," NASA TM 78125, 1977

7. Lueg, RE, "Planning for Material Processing in Space," Grant No. NGT01-002-095, 1977

8. Steg, Leo (Edited by), "Material Sciences in Space with Applications to Space Processing," AIAA Progress in Astronautics, Vol. 52, 1977

B. GENERAL PAPER ON FLUID AND HEAT FLOW

Grodzka, P.G., "Heat Flow and Convection Demonstration Experiments Aboard Apollo 14," Science Vol 176, 1972

Bannister, T.C., "Skylab III and IV Science Demonstrations Preliminary Report," TMX 64835, 1974

Carruthers, J. R., et. al., "The Applications of Drops and Bubbles To The Science Of Space Processing Of Materials," Cal Tech/JPL Colloq. Drops & Bubbles, 1974

Carruthers, J. R., "Studies of Rotating Liquid Floating Zones On Skylab IV," AIAA Publication, 1975

Grodzka, P.G., "Heat Flow and Convection Demonstrations Experiments Aboard Apollo 17," Science Vol 187, 1975

Bannister, T. C., "Post [illegible]ght Analysis of Science Demonstrations," AIAA Progress in Astronautics, Vol 48, 1976

Bannister, T. C., "Use of TV in Space Science Activities: Some Consideration," Applied Optics, Vol 16, 1977

Davidson, M. C., "Narrow Zone Heating by a New Radiation Focusing Technique: Toroidal Ellipsoid Furnace," MSFC 1977

Glicksman, M. E., "Convective Heat Transfer During Dendritic Solidification," AIAA 16th Aerospace Sciences 78-220, 1978

C. ELECTROPHORESIS SEPARATION

Snyder, R.S., "Electrophoresis Demonstration on Apollo 16," NASA TMX 64724, 1972

Snyder, R.S., et. al., "Free Fluid Particle Electrophoresis on Apollo 16," Separation & Purification Methods 2(2), 259-282, 1973

Bier, M., "Electrophoresis in Space at Zero Gravity," AIAA Paper No. 74-210, 1974

Patterson, W.J., "Development of Polymeric Coating for Control of Electro-Osmotic Flow in ASTPMA-11 Electrophoresis," NASA TMX 73311, 1976

Nerren, B.H., "Development of A Slicing Device for ASTP Electrophoresis Technology Experiment MA-11," NASA TMX 73395, 1977

Allen, R.E., et. al., "Column Electrophoresis on the ASTP," Separation and Purification Methods 2(2), 259-282, 1973

D. METALLURGY

1. Lacy, L.L., "The Stability of Liquid Dispersions in Low Gravity," AIAA # 74-1242, 1974

2. Lacy, L.L., et. al., "The Electrical Properties of Zero-Gravity Processed Immiscibles," AIAA No. 74-208, 1974

3. Lacy, L.L., "Preliminary Report on the Physical Properties of Al-Cu Eutectic Samples Processed on Skylab 4," NASA MISC-SSL-74-2, 1974

4. Lacy, L.L., et. al., "Electrical Resistivity of Gallium-Bismuth Solidified in Free Fall," AIAA Journal Vol. 13, No. 2, 1975

5. Snyder, R.S., "Metal Melting, Joining, and Alloying Under Weightlessness," Progress in Astronautics, Vol. 48, 1976

6. McKannan, E.C., "Metallurgical Processing in Space," Progress in Astronautics, Vol. 48, 1976

7. Miller, R.I., "Theoretical Aspects of Undercooling, Nucleation and Growth of Metals in Space," AIAA Journal Spacecraft, 1977

8. Takahashi, S., "Preparation of Silicon Carbide Whisker Reinforced Silver Composite Material in a Weightless Environment," AIAA 15th Aerospace Sciences, 77-195, 1977

9. Gelles, S.H., et. al., "Analytical Study of Space Processing of Immiscible Materials for Superconductors," NASA CR 150156, 1977

10. Johnston, M.H., "The Direct Observation of Solidification as a Function of Gravity Level," Metallurgical Transactions, Vol. 8A, 1977

11. Johnston, M.H., "Compositional Variations in the Undercooled Pb-Sn Eutectic Solidified at Various Accel. Levels,"Metallurgical Scropta, Vol. 11, 1977

12. Gelles, S.H., "Materials Science Experiments in Space," NASA Contractor Report 2842, Contract NAS3-20049, 1978

E. POLYMER CHEMISTRY

1. Kornfeld, D.M., "Large-Size Monodisperse Latexes as a Commercial Space Product," NASA TM 78132, 1977

F. CRYSTAL GROWTH

1. Wiedemeier, H., "Crystal Growth by Vapor Transport of GeSe, $GeSe_2$, and GeTe," Journal of Crystal Growth 13/14, 393-396, 1972

2. Walter, H.U., "Containerless Processing of Single Crystals in Low-G Environment," AIAA, 1974

3. Witt, A.F., et. al., "Crystal Growth and Steady-State Segregation Under Zero Gravity: InSb, J. Electrochemical Soc. 122, 1975

4. Yue, J.T., "Influence of Gravity-Free Solidification on Solute Microsegregation," Journal of Crystal Growth, 1975

5. Grodzka, P.G., "Electrochemical Deposition of Silver Crystals Aboard Skylab IV,"Journal of Crystal Growth 35, 177-184, 1976

6. Walter, H.U., "A Mechanism for Generation of Pulsating Growth and Nonrotational Striations," J. Electrochemical Soc. 123, 1976

7. Davidson, M.C., "On the Dissolation Properties of GaAs in Ga," NASA TMX 73368, 1977

8. Lind, M.D., "Crystal Growth from Solutions in Low Gravity," AIAA 15th Aerospace Sciences Meeting, 77-197, 1977

NOTE: Additional papers may be found in the reports of specific flight results listed under A. Bound Volumes.

G. SPAR III FINAL REPORT
TO BE BOUND AND PUBLISHED IN A SINGLE VOLUME, 1978

Papazian, J. M., "Thermal Migration of Bubbles and Their Interactions With Solidification Interfaces"

Lind, M. D., "Epitaxial Growth of Single Crystal Films SPAR III Final Report"

Schafer, C. F., "Results From Experiments 74-18/2, 3, the SPAR III Liquid Mixing Experiment"

Wouch, G., "Containerless Processing of Beryllium Experiment 74-48"

Uhlmann, D. R., Technical Report on Experiment 74/53 Flown on SPAR III

APPROVAL

SPACE PROCESSING APPLICATIONS BIBLIOGRAPHY

By Program Development

The information in this report has been reviewed for security classification. Review of any information concerning Department of Defense or nuclear energy activities or programs has been made by the MSFC Security Classification Officer. This report, in its entirety, has been determined to be unclassified.

E. C. McKANNAN
Task Team Manager, Space Processing Applications

J. T. MURPHY
Director, Program Development

☆U. S. GOVERNMENT PRINTING OFFICE 1978—740-193/365 REGION NO. 4