# PHOTOGRAPHIC SURVEY OF THE LDEF MISSION

*by*

*Robert L. O'Neal*

*Arlene S. Levine*

*Carol C. Kiser*

National Aeronautics and Space Administration


Langley Research Center
Hampton, Virginia 23681-0001

**NASA Special Publication 531**
**1996**

The use of trademarks or names of manufacturers in this report is for accurate reporting and does not constitute an official endorsement, either expressed or implied, of such products or manufacturers by the National Aeronautics and Space Administration.

Available electronically at the following URL address: http://techreports.larc.nasa.gov/ltrs/ltrs.html

Printed copies available from the following:

NASA Center for AeroSpace Information
800 Elkridge Landing Road
Linthicum Heights, MD 21090-2934
(301) 621-0390

National Technical Information Service (NTIS)
5285 Port Royal Road
Springfield, VA 22161-2171
(703) 487-4650

# Preface

This publication and accompanying CD-ROM present a comprehensive set of high quality reproductions of preflight, in-flight, and postflight photographs of the Long Duration Exposure Facility (LDEF) and the experiments. General descriptions of the LDEF and its mission are also included. The photographs document the effects of more than 5 1/2 years of exposure to the space environment on the spacecraft and the experiments. Therefore, the photographs present a major source of research data.

The text explains where each photograph (e.g., in-flight or in the Spacecraft Assembly and Encapsulation Facility II (SAEF II)) was taken, the location of the experiment on the LDEF, and the notable characteristics of each photograph. The text addresses visual observations rather than detailed analyses. For detailed analyses of the experiments, see NASA Conference Publications 3134, 3194, and 3275, which are the proceedings from the first, second, and third LDEF Post-Retrieval Symposia.

The LDEF Project was initiated during the early development of the Space Shuttle. The project was designed to take advantage of the unique capability of the Space Shuttle to place large payloads in Earth orbit, retrieve these payloads, and return them to Earth. This project marks the first time that direct observation and analysis of the effects of the space environment on a large number of experiments were performed. The project was designed, fabricated, and managed by Langley Research Center in Hampton, Virginia.

We thank all the photographers who documented this project in such a thorough manner at Kennedy Space Center, Johnson Space Center, and Langley Research Center. In-flight photographs were taken by Terry J. Hart (with the assistance of Robert L. Crippen, Francis R. "Dick" Scobee, George D. Nelson, and James D. A. van Hoften) for the deployment mission and Marsha S. Ivins (with the assistance of Daniel C. Brandenstein, James D. Wetherbee, G. David Low, and Bonnie J. Dunbar) for the retrieval mission. Photographs at Kennedy Space Center were taken by George Shelton. The photographers at Langley Research Center included William C. Salyer Jr., Frederick D. Jones, Sandra H. Gibbs, and Don W. Ward.

In addition, we thank all those people at Langley who worked so diligently to put together this publication and the accompanying CD-ROM: William H. C. von Ofenheim, who coordinated the photographic scanning operations and premastering of the CD-ROM; Sharon L. Jenkins and Zylphia E. Wilkins, Computer Sciences Corporation, who painstakingly completed the scanning operation for the CD-ROM; Nancianne Judge, who coordinated the effort to electronically enhance and format the images to be used in the black and white publication; Earl E. Williams, Jr., Margaret P. Hopkins, and Catherine K. Reid, who performed the electronic enhancements and formatted the black and white images; Jack Holm who established electronic tables for the prepress images; Charles T. Brown, Kennedy Space Center, who located many of the negatives from Kennedy Space Center; and Lynn Heimerl and Gail S. McQuigg, who performed the technical editing. We also thank Ricky Hoff, Mary K. McCaskill, Rodney P. Adams, and Donna Roper for their input and support during this project.

The CD-ROM, which accompanies this publication, conforms to the ISO (International Standards Organization) 9660 standards to ensure compatibility across computer platforms. The CD-ROM contains the color versions of all photographs that are reproduced in black and white in this publication. The color photographs were digitized in JPEG (Joint Photographic Experts Group) format, which is a standardized image compression mechanism written by the

Joint Photographic Experts Group. It is a "lossy" image format. That is, a format that uses decompressed images that are not identical to the original uncompressed images, but are designed to depict photographs so that compression anomalies are invisible to the human eye. The CD-ROM also contains the text files that describe each photograph.

The digitized images have the extension ".JPG" to indicate that they are in JPEG format. The figures are batched according to the trays that they depict in the report. Numerous commercial packages exist that support the JPEG format;. however, several viewers are available from the World Wide Web. The following is a list of viewers with locations that are available on the World Wide Web for certain computer platforms:

For X-Windows Systems

Software: XV
Location: ftp.cis.upenn.edu:/pub/xv/

Software: ImageMagick
Location: ftp.x.org:/contrib/applications/ImageMagick/

Software: Xloadimage
Location: ftp.x.org:/R5contrib/

For IBM PC (Windows) Compatible Systems

Software: ACDSee
Location: ftp.coast.net:/SimTel/win3/graphics/

Software: LView Pro
Location: ftp.coast.net:/SimTel/win3/graphics/

Software: WinECJ
Location: ftp.coast.net:/SimTel/win3/graphics/

For IBM PC (DOS) Compatible Systems

Software: DVPEG
Location: sunee.uwaterloo.ca:/pub/jpeg/viewers/

For IBM PC (OS2) Compatible Systems

Software: JoeView
Location: hobbes.nmsu.edu:/os2/graphics/

Software: PMJPEG
Location: hobbes.nmsu.edu:/os2/graphics/

Software: PMView
Location: hobbes.nmsu.edu:/os2/graphics/

For Macintosh Systems

Software: JPEGView
Location: sumex-aim.stanford.edu:/info-mac/gst/grf/

Software: GIFConverter
Location: mac.archive.umich.edu:/mac/graphics/graphicsutil/

Software: GraphicConverter
Location: sumex-aim.stanford.edu:/info-mac/gst/grf/

The full-resolution versions of each of the images and associated text files are also available on the World Wide Web by using a browser. To access these images, open the following uniform resource locator (URL) from any browser:

http://lisar.larc.nasa.gov/LISAR/index.html

The LISAR (Langley image scanning, archival, and retrieval) number associated with each image has been included in the text files for easy search and retrieval.

Also included on the CD-ROM is a table (MATERIAL.TXT) that indicates the materials that were flown on the LDEF along with their locations. This table was condensed from a table that was constructed by Carol Kiser (formerly the LDEF Experiments, Systems, and Integration manager) under Langley contract number NAS1-19247 with Boeing Aerospace Operations, Inc. Mr. Kiser also compiled information for this publication. Mr. Robert L. O'Neal (retired from NASA as the LDEF Project Manager) wrote the text under contract number NAS1-19000 with Lockheed Engineering & Sciences Company and during his retirement. This author thanks them for their efforts.

Arlene S. Levine

# Contents


Preface ..... iii
Contents ..... vii
Acronyms ..... xi
Introduction ..... 1
Description of LDEF ..... 6
Design and Fabrication ..... 6
Experiment Trays ..... 6
Experiment Systems ..... 7
Experiment Power and Data System ..... 7
Experiment Exposure Control Canister ..... 7
Batteries ..... 7
Experiment Initiate System ..... 7
Grapple Fixtures ..... 7
Thermal Control ..... 8
Attitude Control ..... 9
Experiments ..... 9
Deployment Mission ..... 9
Shipment of LDEF to Kennedy Space Center ..... 9
Experiment Integration With Tray ..... 10
Tray Integration With LDEF ..... 10
Deployment Flight ..... 10
Retrieval Mission ..... 10
Retrieval Planning ..... 10
Retrieval Flight ..... 11
Ferry Flight to Kennedy Space Center ..... 12
Postflight Operations at Kennedy Space Center ..... 12
Postflight Observations of Experiment Trays ..... 13
Postflight Observations of LDEF Structure ..... 13
Photographs of Deployment and Retrieval Missions ..... 14
Fabrication and Launch of LDEF ..... 14
Retrieval of LDEF ..... 23
Removal of LDEF From Cargo Bay of Shuttle ..... 35
Photographs of Experiment Trays ..... 46
Tray A1 ..... 46
Tray A2 ..... 51
Tray A3 ..... 56

Tray A4 . . . . . 61
Tray A5 . . . . . 66
Tray A6 . . . . . 68
Tray A7 . . . . . 70
Tray A8 . . . . . 74
Tray A9 . . . . . 79
Tray A10 . . . . . 84
Tray A11 . . . . . 89
Tray A12 . . . . . 94
Tray B1 . . . . . 96
Tray B2 . . . . . 98
Tray B3 . . . . . 100
Tray B4 . . . . . 106
Tray B5 . . . . . 111
Tray B6 . . . . . 116
Tray B7 . . . . . 118
Tray B8 . . . . . 123
Tray B9 . . . . . 128
Tray B10 . . . . . 134
Tray B11 . . . . . 138
Tray B12 . . . . . 140
Tray C1 . . . . . 145
Tray C2 . . . . . 147
Tray C3 . . . . . 152
Tray C4 . . . . . 159
Tray C5 . . . . . 161
Tray C6 . . . . . 162
Tray C7 . . . . . 163
Tray C8 . . . . . 164
Tray C9 . . . . . 169
Tray C10 . . . . . 175
Tray C11 . . . . . 178
Tray C12 . . . . . 183
Tray D1 . . . . . 190
Tray D2 . . . . . 195
Tray D3 . . . . . 199
Tray D4 . . . . . 204

Tray D5 . . . . . 210
Tray D6 . . . . . 215
Tray D7 . . . . . 220
Tray D8 . . . . . 225
Tray D9 . . . . . 230
Tray D10 . . . . . 235
Tray D11 . . . . . 243
Tray D12 . . . . . 248
Tray E1 . . . . . 254
Tray E2 . . . . . 256
Tray E3 . . . . . 261
Tray E4 . . . . . 266
Tray E5 . . . . . 268
Tray E6 . . . . . 274
Tray E7 . . . . . 280
Tray E8 . . . . . 282
Tray E9 . . . . . 287
Tray E10 . . . . . 293
Tray E11 . . . . . 299
Tray E12 . . . . . 301
Tray F1 . . . . . 308
Tray F2 . . . . . 310
Tray F3 . . . . . 314
Tray F4 . . . . . 315
Tray F5 . . . . . 320
Tray F6 . . . . . 322
Tray F7 . . . . . 328
Tray F8 . . . . . 330
Tray F9 . . . . . 334
Tray F10 . . . . . 341
Tray F11 . . . . . 342
Tray F12 . . . . . 344
Tray G2 . . . . . 347
Tray G4 . . . . . 351
Tray G6 . . . . . 352
Tray G8 . . . . . 355
Tray G10 . . . . . 357

Tray G12 . . . . . 361
Tray H1 . . . . . 366
Tray H3 . . . . . 371
Tray H5 . . . . . 376
Tray H6 . . . . . 378
Tray H7 . . . . . 386
Tray H9 . . . . . 391
Tray H11 . . . . . 396
Tray H12 . . . . . 401
Postflight Photographs of Structural Elements Showing Circumferential and Lengthwise Variation of Discoloration . . . . . 406
Photographs of Selected Areas of Discoloration . . . . . 429
References . . . . . 433

# Acronyms

| | |
|---|---|
| ARC | Ames Research Center |
| CERT | Centre d'Etudes et de Recherches de Toulouse |
| CNES | Centre National d'Etudes Spatiales |
| CNRS | Centre National de la Recherche Scientifique |
| CST | Centre Spatial de Toulouse |
| CVCHP | Cascade Variable-Conductance Heat Pipe |
| DERTS | Direction d'Etudes et de Recherches et Techniques Spatiales |
| DFVLR | Deutsche Forschungs- und Versuchsanstalt fÜr Luft- und Raumfahrt |
| EECC | experiment exposure control canisters |
| EIS | experiment initiate system |
| EPDS | experiment power and data system |
| ERB | Earth Radiation Budget |
| ESA | European Space Agency |
| ESTEC | European Space Research and Technology Center |
| EUV | extreme ultraviolet |
| FRECOPA | French cooperative payload |
| GSFC | Goddard Space Flight Center |
| IDE | Interplanetary Dust Experiment |
| JPEG | Joint Photographic Experts Group |
| JPL | Jet Propulsion Laboratory |
| JSC | Johnson Space Center |
| KSC | Kennedy Space Center |
| LaRC | Langley Research Center |
| LATS | LDEF assembly and transportation system |
| LDEF | Long Duration Exposure Facility |
| LeRC | Lewis Research Center |
| LISAR | Langley image scanning, archival, and retrieval |
| LPSP | Laboratoire de Physique Stellaire et Planetaire |
| MSFC | Marshall Space Flight Center |
| MTM | magnetic tape module |
| O & C | Operations and Control |
| ONERA | Office National d'Etudes et de Recherches Aérospatiales |
| OPF | Orbiter Processing Facility |

| | |
|---|---|
| RMS | remote manipulator system |
| SAEF II | Spacecraft Assembly and Encapsulation Facility |
| SBR | space based radar |
| SCU | signal conditioning unit |
| STS | Space Transportation System |
| UV | ultraviolet |
| VDA | vapor-deposited aluminum |

# Introduction

During payload planning in the late 1960's and early 1970's, researchers recognized that the Space Shuttle, with a capability to place large payloads in orbit, to retrieve these payloads, and return them to Earth, offered a new and unique opportunity for the investigation of space environmental effects. Previous flight experiments had to rely on sophisticated instrumentation to relay data to Earth. However, the Space Shuttle could deploy a large spacecraft in Earth orbit for an extended period, and on a later mission, retrieve and return the spacecraft to Earth for visual and laboratory analysis.

Langley Research Center (LaRC) and NASA Headquarters discussed an early concept for such a mission. This early concept was for a recoverable meteoroid experiment to be the primary payload element for a Space Shuttle mission and for the retrieval of the experiment on a subsequent mission. As payload studies continued within NASA and the scientific community, it became apparent that an experiment-carrying payload that accommodated many technical areas would be widely accepted and supported. The Long Duration Exposure Facility (LDEF) was approved for development in July of 1974.

The LDEF was developed and the project was managed by LaRC for the Office of Aeronautics and Space Technology (OAST) of NASA. A diverse group of experiments were selected for the LDEF. These experiments included areas such as ionizing radiation; meteoroid and debris impacts; cosmic dust; high-altitude atomic oxygen effects on materials; and optical, mechanical, electronic, and living systems. The experiments described in reference 1 involved hundreds of investigators from universities, industries, and government laboratories in the United States, Canada, Denmark, France, Germany, Ireland, the Netherlands, Switzerland, and the United Kingdom.

With a full complement of experiments, the LDEF was placed in Earth orbit in April 1984 by the Space Shuttle *Challenger* and retrieved from orbit more than 5 1/2 years later in January 1990 by the Space Shuttle *Columbia*. The LDEF was the first experiment-carrying spacecraft that was flown in space, retrieved, and then returned to Earth. This retrieval enabled investigators to gather data by observation and laboratory analysis of the returned experiments. Extensive preflight, in-flight, and postflight photographic surveys were made of the LDEF and the experiments. The visual interpretation of the experiment and facility hardware provided an added dimension to understanding the effects of the space environment.

This publication documents a selected number of preflight, in-flight, and postflight photographs of the facility and the experiments. It also discusses changes in condition caused by space exposure. Several thousand detailed photographs of the experiments and the facility were taken; however, the nature of this publication precludes including all the photographs. All survey photographs are listed by number and location in a comprehensive index that is available from the LDEF Project Office. Table 1 gives experiment titles, sponsors, and tray numbers.

An overview of the LDEF, the experiments, the mission, and the operations is presented in the following sections for better understanding of the results recorded in the photographs. Information from several documents was used in compiling this document (refs. 1 through 8).

Accompanying this black and white publication is a CD-ROM that contains the color version of the figures, the text, a table of materials flown on the LDEF, and the experiment tray locations. A film scanner, which was connected to a desktop computer, was used to digitize the negatives. The digitized images were saved as TIFF files with dimensions that are roughly 3K × 3K and 24 bits per pixel. A graphic software package was used to convert the images to JPEG format. The images are stored on the CD-ROM by figure number.

Table 1. LDEF Experiments, Sponsors, and Tray Numbers

| Experiment number | Experiment and sponsor | Tray number |
|---|---|---|
| AO015 | Free-Flyer Biostack Experiment<br>Institute for Flight Medicine, DFVLR | C2, G2 |
| AO019 | Influence of Extended Exposure in Space<br>on Mechanical Properties of High-Toughness<br>Graphite-Epoxy Composite Material<br>University of Michigan | D12 |
| AO023 | Multiple Foil Microabrasion Package<br>University of Kent | C3, C9, D12, E6, H11 |
| AO034 | Atomic Oxygen Stimulated Outgassing<br>Southern University<br>NASA MSFC | C3, C9 |
| AO038 | Interstellar Gas Experiment<br>NASA JSC<br>University of Bern | E12, F6, H6,<br>H9 |
| AO044 | Holographic Data Storage Crystals for LDEF<br>Georgia Institute of Technology | E5 |
| AO054 | Space Plasma Voltage High-Voltage Drainage Experiment<br>TRW Space and Technology Group | B4, D10 |
| AO056 | Exposure to Space Radiation of High-Performance<br>Infrared Multilayer Filters and Materials<br>Technology Experiments<br>University of Reading<br>British Aerospace Corporation | B8, G12 |
| AO076 | Cascade Variable-Conductance Heat Pipe<br>McDonnell Douglas Astronautics Company | F9 |
| AO114 | Interaction of Atomic Oxygen With Solid<br>Surfaces at Orbital Altitudes<br>The University of Alabama in Huntsville<br>NASA MSFC | C3, C9 |
| AO133 | Effect of Space Environment on Space-Based<br>Radar Phased-Array Antenna<br>Grumman Aerospace Corporation | H7 |
| AO134 | Space Exposure of Composite Materials for Large<br>Space Structures<br>NASA LaRC | B9 |
| AO135 | Effect of Space Exposure on Pyroelectric<br>Infrared Detectors<br>NASA LaRC | E5 |
| AO138-1 | Study of Meteoroid Impact Craters on<br>Various Materials<br>CERT/ONERA-DERTS | B3 |
| AO138-2 | Attempt at Dust Debris Collection With<br>Stacked Detectors<br>CERT/ONERA-DERTS | B3 |

Table 1. Continued

| Experiment number | Experiment and sponsor | Tray number |
|---|---|---|
| AO138-3 | Thin Metal Film and Multilayers Experiment<br>CNRS<br>LPSP | B3 |
| AO138-4 | Vacuum-Deposited Optical Coatings Experiment<br>Optical Division, Matra S. A. | B3 |
| AO138-5 | Ruled and Holographic Gratings Experiment<br>JOBIN-YVON Division, Instruments S.A. | B3 |
| AO138-6 | Thermal Control Coatings Experiment<br>CERT/ONERA-DERTS<br>CNES/CST | B3 |
| AO138-7 | Optical Fibers and Components Experiment<br>CERT/ONERA-DERTS | B3 |
| AO138-8 | Effect of Space Exposure of Some Epoxy Matrix Composites on Their Thermal Expansion and Mechanical Properties<br>Space Division, Matra S. A. | B3 |
| AO138-9 | The Effect of the Space Environment on Composite Materials<br>Aérospatiale | B3 |
| AO138-10 | Microwelding of Various Metallic Materials Under Ultravacuum<br>Aérospatiale | B3 |
| AO139A | Growth of Crystals From Solutions in Low Gravity<br>Rockwell International Science Center<br>Technical University of Denmark | G6 |
| AO147 | Passive Exposure of Earth Radiation Budget Experiment Components<br>The Eppley Laboratory, Inc. | B8, G12 |
| AO171 | Solar Array Materials Passive LDEF Experiment<br>NASA MSFC<br>NASA LeRC<br>NASA GSFC<br>Jet Propulsion Laboratory | A8 |
| AO172 | Effects of Solar Radiation on Glasses<br>NASA MSFC<br>Vanderbilt University | D2, G12 |
| AO175 | Evaluation of Long Duration Exposure to the Natural Space Environment on Graphite-Polyimide and Graphite-Epoxy Mechanical Properties<br>Rockwell International Corporation | A1, A7 |
| AO178 | A High-Resolution Study of Ultraheavy Cosmic Ray Nuclei<br>Dublin Institute for Advanced Studies<br>ESA, ESTEC | A2, A4, A10, B5, B7, C5, C6, C8, C11, D1, D5, D7, D11, E2, E10, F4 |

Table 1. Continued

| Experiment number | Experiment and sponsor | Tray number |
|---|---|---|
| AO180 | The Effect of Space Environment Exposure on the Properties of Polymer Matrix Composite Materials<br>University of Toronto | D12 |
| AO187-1 | The Chemistry of Micrometeoroids<br>NASA JSC<br>University of Washington<br>Rockwell International Science Center | A3, A11 |
| AO187-2 | Chemical and Isotopic Measurements of Micrometeoroids by Secondary Ion Mass Spectrometry<br>McDonnell Center for the Space Sciences<br>Max-Planck Institute for Nuclear Physics<br>Munich Technical University<br>Ernst-Mach Institute<br>Dornier System Manufacturing Company | C2, E3, E8 |
| AO189 | Study of Factors Determining the Radiation Sensitivity of Quartz Crystal Oscillators<br>Martin Marietta Laboratories | D2 |
| AO201 | Interplanetary Dust Experiment<br>Institute for Space Science and Technology<br>NASA LaRC<br>North Carolina State University | B12, C3, C9, D6, G10, H11 |
| M0001 | Heavy Ions in Space<br>Naval Research Laboratory | H3, H12 |
| M0002-1 | Trapped Proton Energy Spectrum Determination<br>Air Force Geophysics Laboratory<br>NASA MSFC<br>Army Materials and Mechanics Research Center<br>Clarkson College of Technology<br>Emmanuel College<br>Eastern Kentucky University | D3, D9, G12 |
| M0002-2 | Measurement of Heavy Cosmic Ray Nuclei on LDEF<br>University of Kiel | E6 |
| M0003 | Space Environment Effects on Spacecraft Materials<br>The Aerospace Corporation | D3, D4, D8, D9 |
| M0004 | Space Environment Effects on Fiber Optics Systems<br>Air Force Weapons Laboratory | F8 |
| M0006 | Space Environment Effects<br>Air Force Technical Applications Center<br>Perkin-Elmer<br>Grumman Aerospace Corporation<br>The City College | C2 |
| P0003 | LDEF Thermal Measurements System<br>NASA LaRC | Center Ring |

Table 1. Concluded

| Experiment number | Experiment and sponsor | Tray number |
|---|---|---|
| P0004-1 | Seeds in Space Experiment<br>George W. Park Seed Company, Inc. | F2 |
| P0004-2 | Space-Exposed Experiment Developed for Students<br>NASA Headquarters | F2 |
| P0005 | Space Aging of Solid Rocket Materials<br>Morton-Thiokol, Inc. | Center Ring |
| P0006 | Linear Energy Transfer Spectrum Measurement Experiment<br>University of San Francisco<br>NASA MSFC | F2 |
| S0001 | Space Debris Impact Experiment<br>NASA LaRC | A5, A6, A12, B1, B2, B6, B8, B11, C4, C7, D2, D6, E1, E4, F7, E7, E11, F1, F3, F5, F10, F11, G4, G8, H5 |
| S0010 | Exposure of Spacecraft Coatings<br>NASA LaRC | B9 |
| S0014 | Advanced Photovoltaic Experiment<br>NASA LeRC | E9 |
| S0050 | Investigation of the Effects of Long Duration Exposure on Active Optical System Components<br>Georgia Institute of Technology | E5 |
| S0050-1 | Investigation of the Effects of Long Duration Exposure on Active Optical Materials and UV Detectors<br>NASA LaRC | E5 |
| S0050-2 | Optical Substrates and Coatings Experiment<br>NASA LaRC | E5 |
| S0069 | Thermal Control Surfaces Experiment<br>NASA MSFC | A9 |
| S0109 | Fiber Optic Data Transmission Experiment<br>Jet Propulsion Laboratory | C12 |
| S1001 | Low-Temperature Heat Pipe Experiment Package for LDEF<br>NASA GSFC<br>NASA ARC | F12, H1 |
| S1002 | Investigation of Critical Surface Degradation Effects on Coatings and Solar Cells Developed in Germany<br>Space Division, Messerschmitt-Bolkow-Blohm | E3 |
| S1003 | Ion-Beam-Textured and Coated Surfaces Experiment<br>NASA LeRC | E6 |
| S1005 | Transverse Flat-Plate Heat Pipe Experiment<br>NASA MSFC<br>Grumman Aerospace Corporation | B10 |
| S1006 | Balloon Materials Degradation<br>Texas A&M University | E6 |

# Description of LDEF

## Design and Fabrication

Design guidelines were for LDEF to take advantage of the large weight carrying capability of the shuttle, expose a maximum surface area, and utilize one half of the Shuttle cargo bay volume. A design goal was to utilize simple, low cost fabrication techniques and commercially available materials. The result was a 12-sided, 14-ft-diameter, 30-ft-long aluminum open grid structure. The main load carrying element of the structure was a center ring. Longerons attached to the center ring spanned the distance between the center ring and end frames. Intercostals placed at intervals spanned the longerons. The structure was equipped with 4 trunnions (two on the center ring and two on an end support beam) and a keel pin for attachment in the cargo bay of the Shuttle. The LDEF was also equipped with two grapple fixtures for the remote manipulator system of the Shuttle. Some of the fabrication sequence is shown in figures 1 through 5. The LDEF total weight was approximately 21400 lbs, which included 8900 lbs of structural and systems components and 12500 lbs of trays and experiments.

Prior to final assembly, structural surfaces that faced the interior of LDEF were painted with Chemglaze Z306 black paint for thermal control. The bolts, fasteners, trunnions, keel pin, and end support beam spindle were made of nonmagnetic stainless steel.

The LDEF structural configuration with locations of the experiments is shown in figure 6. For mounting experiment trays, the structure had 72 equal-sized rectangular openings on the sides and 14 openings on the ends (6 on the Earth-facing end and 8 on the space-facing end). The 12 sides of the structure are numbered rows 1 through 12 in a clockwise direction when facing the end with the end support beam (the Earth-facing end in orbit). The six longitudinal locations are identified alphabetically as bays A through F, starting at the end with the support beam. A tray location is designated by the bay and row numbers, such as A1, B5, or F8. Trays on the Earth-facing end are designated by the letter G with the locations designated by even-number clock positions (G2, G4, G6, G8, G10, and G12). The space-facing end is designated by the letter H with the location designations following the same convention (H1, H3, H5, H6, H7, H9, H11, and H12).

## Experiment Trays

LDEF experiments were self-contained in trays that were clamped to the facility structure. The LDEF had 72 peripheral and 14 end experiment trays. To accommodate the diverse experiment requirements and characteristics, the trays were of five standard sizes: 3-in-deep, 6-in-deep, and 12-in-deep peripheral trays and 6-in-deep and 12-in-deep end trays. All trays were constructed of 6061-T6 anodized aluminum. Figure 7 is a photograph of the three sizes of peripheral trays. The overall approximate dimensions of these trays were 53 in. by 42 in. The end trays were slightly smaller in size.

Each tray was attached to the LDEF structure by clamp assemblies. Some of the tray clamps had white dots (discs) painted on them as a visual aid in an attempt to measure spacecraft motions (pitch, roll, and yaw) from video and photographs made at deployment. The dots were made of Chemglaze A276 white paint and Chemglaze Z306 black paint. The bottoms of all tray frames and the sides of all tray walls facing the interior of LDEF were painted with Chemglaze Z306 black paint for thermal control.

## Experiment Systems

The LDEF had no telemetry or central power system. Although LDEF was essentially passive, it did supply some tray-contained data processing and recording, experiment environment control, and battery power to a limited number of experiments.

***Experiment Power and Data System.*** Seven experiment trays had a self-contained experiment power and data system (EPDS) provided by LaRC. These experiments were located in trays D4, D8, F8, E9, B10, B12, and F12. The EPDS was designed to provide data collection and storage for those experiments with such a requirement. The EPDS consists of a data processor controller assembly, a magnetic tape module (MTM), and a primary battery source. The MTM provided storage of approximately 14 megabits of data. Data recorded during flight was retrieved postflight after experiment and systems were removed. Electrical power was supplied by batteries in each of the seven trays.

***Experiment Exposure Control Canister.*** Five experiment trays had experiment exposure control canisters (EECC) provided by LaRC. They were located in trays C2, E3, D4, D8, and B9. The EECC were self-contained automated experiment canisters capable of opening and closing during flight. The schedule of opening and closing was programmed before flight. Electrical power was supplied by batteries located in each of the five trays. The canisters were closed before flight and remained closed until cycled while in orbit.

***Batteries.*** The lithium sulphur dioxide (LiSO2) batteries used on LDEF were developed by LaRC and provided to experimenters. The batteries had three nominal capacities: 7.5, 12, and 28 volts. A 7.5-volt battery provided power to each EPDS and a 12-volt battery provided power for each tape recorder. Power was supplied to each EECC by 7.5-volt and 28-volt batteries. Batteries of each capacity were used as required to power experiments. Other batteries were used on two experiments. Nickel cadmium (NiCd) batteries were used on the Low-Temperature Heat Pipe Experiment (S1001) in tray F12 and lithium carbon fluoride (LiCF0) batteries were used on the Thermal Control Surfaces Experiment (S0069) located in tray A9.

***Experiment Initiate System.*** The experiment initiate system (EIS) was designed to send an on (set) or an off (reset) signal to each active experiment when microswitches located on the rigidize sensing grapple fixture were activated. The EIS was self-contained and had no interface with the Shuttle. Status indicators, which were located in tray C10 in view of the RMS wrist camera, would be white to indicate "set" (on) or black to indicate "reset" to indicate (off). These indicators are visible in photographs of that experiment tray. The EIS was turned on in orbit prior to LDEF deployment by cycling the rigidize sensing grapple fixture with the Shuttle RMS while LDEF was still latched in the bay. It was originally planned to deactivate the EIS after retrieval and LDEF had been latched in the bay; however, due to the extended length of the mission, the existing "set" status was preserved so that systems studies of long term effects could be conducted after tray removal.

## Grapple Fixtures

The LDEF had two grapple fixtures each located in part of a 6-in-deep experiment tray. These fixtures were standard Space Transportation System (STS) hardware items provided by NASA Johnson Space Center (JSC) and served as the interface between the LDEF and the

Shuttle RMS. A standard grapple fixture was located in tray C1 and a rigidize sensing grapple fixture was located in tray C10.

The standard grapple fixture in tray C1 was used for deployment and retrieval of LDEF by the RMS. The chevron painted in the bottom of the tray is a visual aid for the crew to use for LDEF retrieval. The grapple target on either fixture aids the RMS operator in positioning the end effector over the grapple spike for capture.

The rigidize sensing grapple fixture in tray C10 differed from the standard fixture in that the grapple spike of the rigidize sensing grapple was spring loaded and moved approximately 1 in. during the RMS end effector rigidization. This movement of the grapple spike shaft activated microswitches in the EIS circuit. This feature allowed the fixture to be utilized as an on and off switch for the EIS.

## Thermal Control

The LDEF thermal design was completely passive. The design relied on surface coatings and internal heat paths for temperature control and equalization. The thermal modeling and design of the LDEF and the flight results are covered extensively in references 2 through 5.

The gravity gradient stabilization of LDEF with one end pointing toward Earth and the maintaining of a leading and trailing side (row 9 leading and row 3 trailing) resulted in unique thermal environments for experiments around the periphery. The thermal environment for all experiments varied due to the occurrence once per orbit of day and night, precession of the LDEF orbit, and the yearly cycle of solar angle. The attitude of LDEF caused experiments in rows 11, 12, and 1 or rows 4, 5, and 6 to face the sun or space for extended periods of time.

The primary means of achieving temperature control of the LDEF and the experiments was by the placement of experiments on the facility and the selection of thermal control coatings. Over 90 percent of the interior surfaces were painted with Chemglaze Z306 high emissivity black paint (e = 0.90). This paint minimized any circumferential thermal gradients and maximized the radiation heat transfer across the facility (ref. 2). A photograph of the interior of the facility is shown in figure 670. As discussed in reference 2, the even distribution of experiments with given thermal properties was the primary method of thermal control of LDEF. Experiments were placed in a checkerboard arrangement to equalize thermal properties over the surfaces of LDEF. The placement and the thermal properties of the anodized surfaces of the trays for the Space Debris Impact Experiment (S0001) was the major thermal design variable. The surface of these trays and that of the aluminum structure and experiment tray flanges of the LDEF were over 50 percent of the thermal control surface area. The external thermal properties of the tray flanges and the witness plates of experiment S0001 were left undefined until the experiment complement was defined. Using the thermal model of the LDEF, the required thermal properties of these surfaces were determined. The tray flanges and surfaces of experiment S0001 were then chromic anodized to provide the required properties.

The prelaunch, launch, and in-flight environment of the Shuttle cargo bay was maintained at temperatures less extreme than the free-flying environment of the LDEF. The heat soak and resultant temperature increase after landing was maintained within acceptable limits by preconditioning the large mass of LDEF prior to reentry and by ground purge cooling after landing.

## Attitude Control

The LDEF had no active attitude control system; instead, it relied on gravity gradient torques and preselected moment of inertia ratios to provide the control. Gravity gradient torques maintained the LDEF in a position in which the axis of minimum moment of inertia was aligned with the local vertical. This alignment resulted in one end of LDEF always pointing toward the Earth and the other end always pointing toward space. Coupling torques from small preestablished differences in the transverse moments of inertia stabilized the facility about its longitudinal axis and resulted in one side always pointing in the direction of flight. Such coupling torques are discussed in reference 6. The LDEF was precisely positioned by the RMS and released with its longitudinal axis aligned with the local vertical and preferred end facing Earth. Row 9 was facing in the direction of the velocity vector as the preferred leading side. Figure 8 illustrates the LDEF orientation in orbit.

A viscous magnetic rate damper was selected to provide damping should significant motions occur at LDEF deployment. Such damping would ensure capture in a gravity gradient with one end toward earth. Dampers of this type had been successfully flown on other spacecraft. Comprehensive stability analyses of the LDEF were conducted to define damper performance requirements and are reported in references 7 and 8. The damper that was flown is shown in a postflight photograph in figure 63.

For the relatively brief period of observations by the flight crew after deployment of the LDEF, no significant motions were apparent. The results of postflight analyses discussed in reference 9 indicated that the LDEF was yawed slightly from the attitude of row 9 facing forward during the mission. The yaw angle was approximately 8° clockwise when viewed from the space end. This angle represented a leading edge bias from the row 9 side slightly toward row 10. Analyses also indicated that the LDEF had a slight pitch with the space end of the forward facing side canted forward approximately 2°.

## Experiments

Table 1 lists the LDEF experiment complement with the respective sponsors and tray numbers. Figure 9 shows the location of each experiment on LDEF. These experiments addressed areas such as ionizing radiation; meteoroid and debris impacts; cosmic dust; high-altitude atomic oxygen effects on materials; and optical, mechanical, electronic, and living systems. The 57 experiments selected for LDEF involved several hundred investigators from universities, industries, and government laboratories in the United States and many foreign countries.

# Deployment Mission

## Shipment of LDEF to Kennedy Space Center

The last task in the fabrication of LDEF at LaRC was installation and checkout of the experiment initiate system and the experiment interconnect wiring harness (fig. 5). After the Preship Readiness Review, the facility was shipped to KSC on the Landing Craft Utility (LCU) inside the environmentally controlled (humidity and temperature) LDEF Assembly and Transportation System (LATS). The LDEF arrived at KSC on June 21, 1983 and was placed in temporary storage to await the start of integration operations.

### Experiment Integration With Tray

Experiments were integrated with trays either at LaRC or at experimenters' facilities. After integration, all trays were certified by vibration tests approved by STS to verify structural integrity and safety for flight. After testing, all experiments were shipped to KSC for integration with the LDEF. Experiments were shipped in sealed containers with a dry nitrogen atmosphere.

### Tray Integration With LDEF

The shipment of all flight hardware and associated ground support equipment to KSC was completed in October of 1983. Activities to prepare LDEF for launch began on November 1. Activities for LDEF integration were conducted in the KSC Spacecraft Assembly and Encapsulation Facility II (SAEF II). The LATS with the LDEF inside was moved into the SAEF II clean room along with experiment tray shipping containers. Each experiment tray was inspected, photographed, and installed on the LDEF and the EIS was checked.

Photographs taken of the experiment trays and photographs of the facility after experiment tray integration are a part of this document. Overall views of the LDEF after experiment installation are shown in figures 10 through 13. After experiment trays and other systems were installed, the LDEF was weighed. The center of gravity was established and adjusted to within preselected limits by adding lead ballast plates to the interior of the end frames.

The LATS cover was reinstalled after integration was complete. The LATS with the LDEF inside was transported to the KSC Operations and Checkout (O & C) building where the LDEF was installed in the KSC Payload Canister. In March 1984, the LDEF and the Solar Max Repair Module were inserted into the Shuttle cargo bay at the launch pad. Figure 14 shows this operation.

### Deployment Flight

The STS 41-C flight was launched on April 6, 1984. Figure 15 is a photograph of the liftoff. On April 7, the RMS was used to activate the EIS and then to deploy the LDEF in a gravity gradient stabilized attitude. Figure 16 shows the LDEF on the RMS arm after removal from the cargo bay with the Florida peninsula visible in the background. The LDEF was deployed in a near-circular orbit at an altitude of 257 n.mi. Figure 17 is a photograph of the LDEF soon after release. After release, the Shuttle was maneuvered away from the LDEF to minimize any contamination by the Shuttle propulsion or reaction control system. While the LDEF was visible, the Shuttle crew noted no unwanted facility motions.

After completion of the repair and redeployment of the Solar Max satellite, the shuttle landed at Edwards Air Force Base in California. Figure 18 is a photograph of the landing.

## Retrieval Mission

### Retrieval Planning

When LDEF was launched in April 1984, the retrieval was scheduled for March 19, 1985, on STS 51-D. In early February 1985 shortly before the scheduled retrieval, the flight manifest was changed to accommodate another payload and the LDEF retrieval was delayed

indefinitely. In January 1986 the *Challenger* accident resulted in all Shuttle flights being temporarily halted.

When it became apparent that the LDEF retrieval would be delayed by years, orbit lifetime studies were initiated at LaRC and JSC to better plan the retrieval. The results of these studies are discussed in reference 9. In August 1986, LaRC studies indicated that LDEF reentry could occur between fall 1990 and spring or summer 1991. A large uncertainty was the effect of the solar flux expected from solar cycle 22. The first post-*Challenger* manifest published in March 1988 scheduled the LDEF retrieval on STS 32 in July 1989. The August 1988 manifest scheduled the STS 32 launch in November of 1989. This launch date appeared to be an adequate margin of approximately 1 year in orbit lifetime.

As discussed in reference 9, the LDEF was launched at a time of near-minimum activity in the 11-year solar cycle. Because of delays, the retrieval would be near the time of near-maximum solar activity. In early 1988, it was becoming apparent that solar cycle 22 was more severe than normal and was resulting in a significant decrease in orbital lifetime expectancy. In June 1989, the reentry was predicted to be late January 1990. Since the retrieval flight was now scheduled for December 18, 1989, concern for the successful retrieval of LDEF was mounting. In December 1989, problems with refurbishment of the launch pad caused the launch date to be rescheduled for January 8, 1990. After a one day delay due to weather, the retrieval mission was launched on January 9, 1990. The LDEF was retrieved on January 12, some 58 months later than originally planned in 1984. The history of the orbit altitude and the decay rate for the late stages of the mission is discussed in reference 9.

## Retrieval Flight

The LDEF retrieval mission included the deployment of SYNCOM IV-5, and a mid-deck experiment with the IMAX camera. The Interim Operational Contamination Monitor (IOCM) was carried in the cargo bay and provided quantitative data on the environmental contamination that was experienced by the LDEF during the retrieval and reentry phases of the mission. Constraints were placed on the rendezvous operations, proximity operations, and operations after capture and return of the LDEF to KSC so that the retrieved LDEF would be, as nearly as possible, in the same condition as it was in space at the end of the 69-month mission.

The retrieval flight was launched into a $190 \times 161$ n.mi. orbit at an inclination of 28.5°. Figure 19 is a photograph of the liftoff. The SYNCOM IV-5 was deployed on flight day 2. The orbit-phasing maneuvers then began for rendezvous with LDEF which was in a circular orbit of 179 n.mi. Figure 20 is a photograph of the LDEF as the Shuttle approached the velocity vector from below. The planned capture maneuver was for the orbiter to pass 300 ft (actual position 590 ft) in front of the flight path of the LDEF, inverted to a position 300 ft (actual position 230 ft) above LDEF and to descend in this inverted position along the radius vector axis for capture. This maneuver above the radius vector axis minimized contamination of LDEF by the firing of the reaction control system (RCS). As the shuttle neared the LDEF, a small solar array that had recently become dislodged from one of the experiments was seen flying in formation with LDEF. Figure 21 is a photograph of this array. Figure 22 is a photograph of the LDEF as the Shuttle approached from above along the radius vector axis with the RMS poised for the final maneuver to capture. The LDEF was captured, with the grapple fixture in tray C1, at 9:16 a.m. central standard time on orbit 50 over the Atlantic Ocean east of Brazil.

After capture, a detailed photographic and visual survey of the LDEF was made. This survey was done to document the condition of each experiment prior to undergoing the rigors of reentry, landing, and the flight back to KSC. The RMS was used to orient the LDEF so that photographs of the overall spacecraft and of each experiment tray could systematically be taken. Photographs were taken using Kodak 5017 (Ektachrome 64) film. The JSC photographic lab processed the film and provided the project with duplicate negatives and prints. The original processed film is archived at JSC. Selected photographs from this extensive survey are presented in this publication.

Overall views of the LDEF are shown in figures 23 through 41. The detailed photographs of each tray are shown as a part of the comparative survey.

After completion of the photographic survey, the LDEF was berthed in the cargo bay and the keel pin latched on orbit 54 at 2:40 p.m. central standard time over the Indian Ocean.

The orbiter was positioned near the end of the 11-day mission to thermally condition the LDEF so that experiment temperatures during reentry and landing would not exceed in-flight temperatures. A photograph of the predawn landing on January 20 at Edwards Air Force Base is shown in figure 42. After landing and roll-out, ground purge of the shuttle payload bay maintained the desired payload bay environment. During the 69 months in orbit, the LDEF had completed 32422 orbits of the Earth and travelled over 741928999 n.mi.

A photographic survey was made of the end of LDEF facing the cargo bay access hatch prior to the Shuttle being mounted on the ferry aircraft. Figure 43 is an overall view of the space-facing end of LDEF. Selected detailed photographs from this survey are presented herein.

## Ferry Flight to Kennedy Space Center

Prior to the Shuttle being mounted on the ferry aircraft, special instrumentation was placed in the cargo bay to monitor and record environmental conditions during the ferry flight to KSC.

The ferry flight, which included three 747 refueling stops and an overnight stay, was completed on January 26. To maintain LDEF experiments and systems in the as-retrieved condition, a purge of the cargo bay was used at the intermediate stops on the ferry flight and during the demate and tow to the Orbiter Processing Facility (OPF) at KSC. The transfer to the OPF on January 27 started the "on-line" processing at KSC.

## Postflight Operations at Kennedy Space Center

Figures 44 and 45 show operations in the KSC OPF where the LDEF was removed from the orbiter cargo bay and placed in the Payload Canister for transfer to the O & C building. During operations in the OPF, many photographs were taken of the facility as well as each visible experiment tray. Some of these photographs are presented herein.

After LDEF was transferred to SAEF II for deintegration operations, a photographic survey was made of the facility and the individual experiment trays before disassembly began. Figures 46 through 59 show views of the facility which may be compared with preflight photographs. Some individual tray photographs are shown as a part of the comparative survey. Figures 60 and 61 are photographs of the LDEF after most trays had been removed. Figures 62 and 63 show the damper protective cover and the damper after removal from LDEF.

## Postflight Observations of Experiment Trays

After experiment trays were removed from the LDEF, detailed photographs were made of each tray. Many of these photographs are presented for comparison with preflight and in-flight photographs in figures 64 through 623.

Visual evidence of contamination was found on experiments, trays, and the facility. The LDEF was found to have a light brown coating on many of these surfaces. The contamination was more concentrated in some areas than in others. Surfaces on the leading side of LDEF, the side facing forward in flight, were "cleaner." Indications were that surfaces that had become contaminated were cleaned to a degree by atomic oxygen, which was encountered in the final low altitude phase of the mission.

It was difficult to consistently ascertain the presence or degree of contamination on anodized aluminum surfaces. The visibility of this contamination depended greatly on the lighting, the lighting angle, and the camera angle. The most reliable method of judging the presence and the variation of contamination was to use the white dots on the tray clamps as a reference. The dots in the photographs that were taken in flight are white on the forward facing rows of experiments and dark brown on the trays facing in the trailing direction.

## Postflight Observations of LDEF Structure

Many photographs recorded the condition of all facility interior and exterior surfaces. Postflight inspection of the interior surfaces showed varying patterns of discoloration. Photographs were taken of the longeron interior surfaces to show how these discolorations varied around the periphery and along the length of LDEF. These photographs are shown in figures 624 through 668. Evidence of contamination observed on a few other surfaces are shown in figures 669 through 675.

# Photographs of Deployment and Retrieval Missions

## Fabrication and Launch of LDEF

***Figure 1 (Preflight).*** In this figure, the LDEF center ring fabrication is shown as it nears completion in the fabrication shop at LaRC in 1977. The center ring was heat-treated and drilled for trunnions. A keel pin and the interior surfaces were painted before final assembly of the facility. This ring was the principal load-carrying element of the LDEF.

Figure 1
Photo No.: L77-07820
LISAR No.: EL-1994-00717
Photo Credit: LaRC
Location: LaRC Fabrication Shop in Building 1232
Subject: Fabrication of Center Ring

***Figure 2 (Preflight).*** Longerons were bolted to the center ring for the initial structure buildup. Interfacing elements of the center ring and longerons had been match drilled and marked to ensure a proper fit in the final assembly.

Figure 2
Photo No.: L78-03258
LISAR No.: EL-1994-00325
Photo Credit: LaRC
Location: LaRC Fabrication Shop in Building 1232
Subject: Preliminary Assembly of LDEF

***Figure 3 (Preflight).*** In this figure, the initial buildup of half of the LDEF has been completed. This buildup was then disassembled, the center ring was turned over, and the other half of the LDEF was drilled and assembled. After disassembly, the interior-facing surfaces of all structural elements were painted with high-emissivity black paint for thermal control in flight.

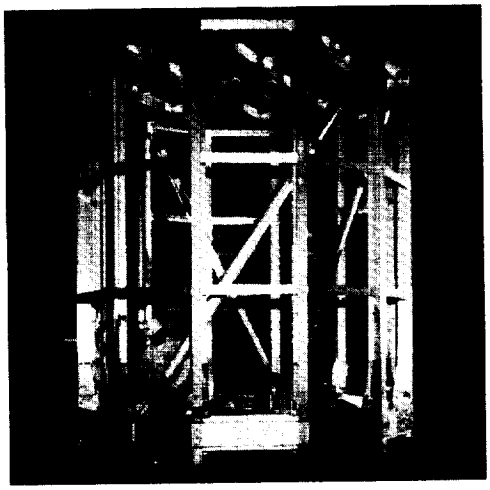

Figure 3
Photo No.: L78-03484
LISAR No.: EL-1994-00374
Photo Credit: LaRC
Location: LaRC Fabrication Shop in Building 1232
Subject: Preliminary Assembly of LDEF

***Figure 4 (Preflight).*** This photograph shows the final buildup of the facility on LATS as it was nearing completion in the fabrication shop. Covers and wrappings protected the surfaces from damage.

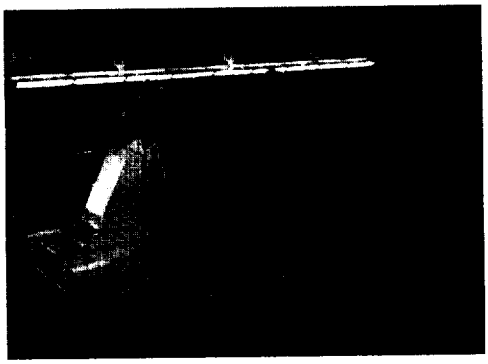

Figure 4
Photo No.: L78-05723
LISAR No.: EL-1994-00388
Photo Credit: LaRC
Location: LaRC Fabrication Shop in Building 1232
Subject: Final Assembly of LDEF

***Figure 5 (Preflight).*** The wiring harness was installed prior to shipment of the facility to KSC. The wiring harness connected the experiment initiate system to the appropriate experiment trays and interconnected some experiment trays.

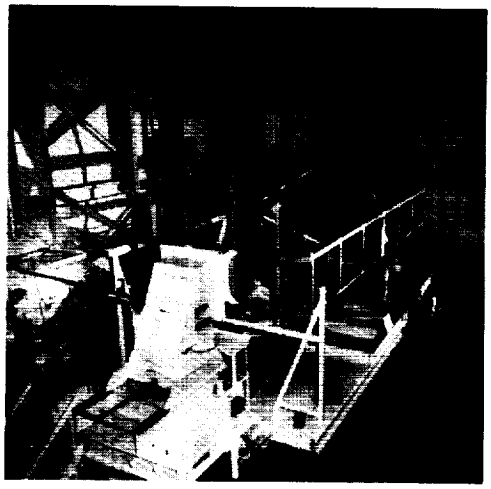

Figure 5
Photo No.: L83-02796
LISAR No.: EL-1994-00702
Photo Credit: LaRC
Location: LaRC Building 1250
Subject: Installation of Wiring Harness

***Figure 6 (Preflight).*** A sketch shows the identification and the location of experiment trays on the LDEF. Other pertinent features are also noted.

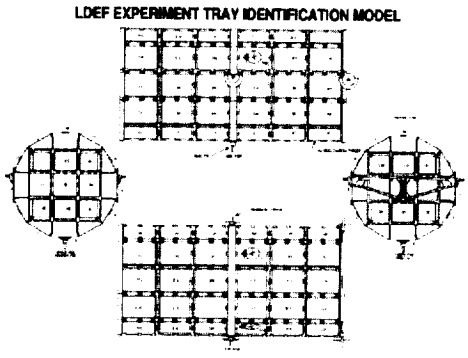


Figure 6
Photo No.: L95-01323
LISAR No.: EL-1994-00557
Photo Credit: LaRC
Subject: Sketch of Experiment Identification Logic

***Figure 7 (Preflight).*** The LDEF had 72 peripheral and 14 end experiment trays that were clamped to the facility structure. The standard depth sizes were 3 in., 6 in., and 12 in. for the peripheral trays and 6 in. and 12 in. for the end trays. This photograph shows the three sizes of peripheral trays. The approximate length and width dimensions were 53 in. by 42 in. The end trays were slightly smaller. The surfaces facing the interior of the LDEF were painted with high-emissivity black paint for thermal control.

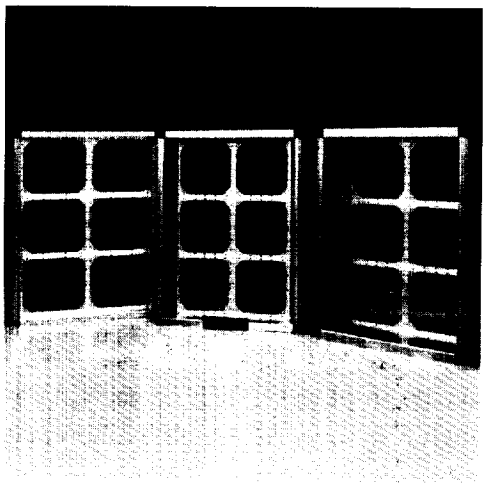

Figure 7
Photo No.: L76-03431
LISAR No.: EL-1994-00716
Photo Credit: LaRC
Location: LaRC Fabrication Shop in Building 1232
Subject: Sizes of Peripheral Experiment Trays

***Figure 8 (Preflight).*** The LDEF did not have an active attitude control system. Gravity gradient torques and preestablished differences in transverse moments of inertia resulted in one end pointing toward Earth and a preferred leading side. This photograph illustrates the LDEF orientation in flight.

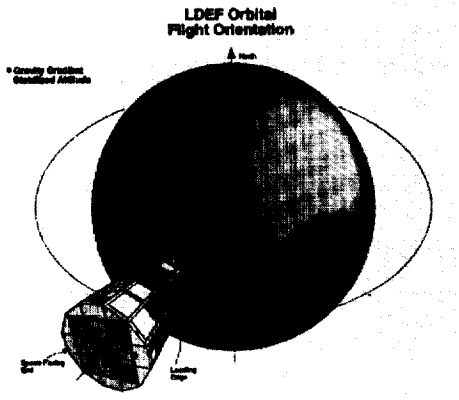


Figure 8
Photo No.: L91-00652
LISAR No.: EL-1994-00590
Photo Credit: LaRC
Subject: Orbital Attitude of LDEF

***Figure 9 (Preflight).*** Experiment locations on the LDEF are shown in this sketch.

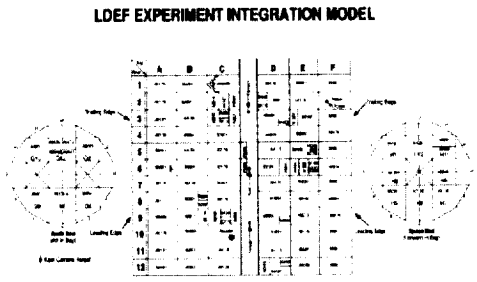


Figure 9
Photo No.: L95-001324
LISAR No.: EL-1994-00560
Photo Credit: LaRC
Subject: Experiment Locations

***Figure 10 (Preflight).*** In this figure, a preflight photograph of the LDEF on the LATS in the SAEF II at KSC provides a side view of bays A through F in rows 2 through 5 after experiment installation.

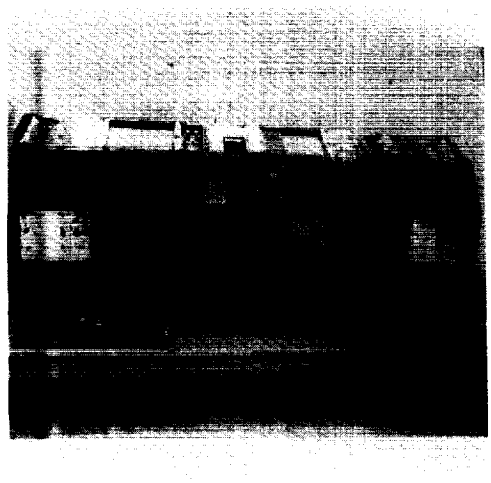

Figure 10
Photo No.: KSC-384C-419.17
Dup. Neg. No.: L84-07237
LISAR No.: EL-1994-00587
Photo Credit: KSC
Location: In SAEF II at KSC
Subject: Experiments Installed in Bays A Through F in Rows 2 Through 5

***Figure 11 (Preflight).*** In this figure, a preflight photograph, which was taken of the LDEF on the LATS, provides a side view of the LDEF bays A through F in rows 6 through 9 after experiment installation.

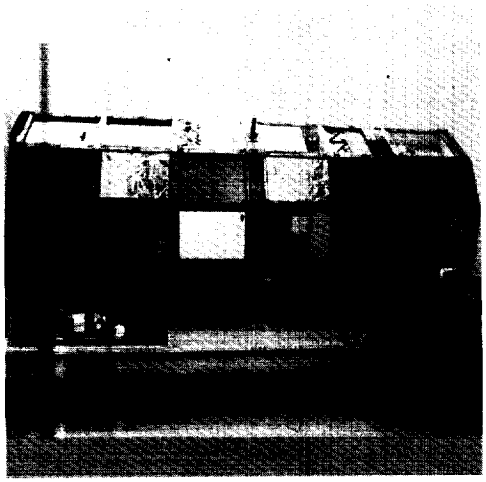

Figure 11
Photo No.: KSC-384C-419.29
Dup. Neg. No.: L84-07249
LISAR No.: EL-1994-00558
Photo Credit: KSC
Location: In SAEF II at KSC
Subject: Experiments Installed in Bays A Through F in Rows 6 Through 9

***Figure 12 (Preflight).*** A preflight photograph, which was taken of the LDEF on the LATS, provides a side view of the LDEF bays A through F in rows 10, 11, 12, and 1 after experiment installation.

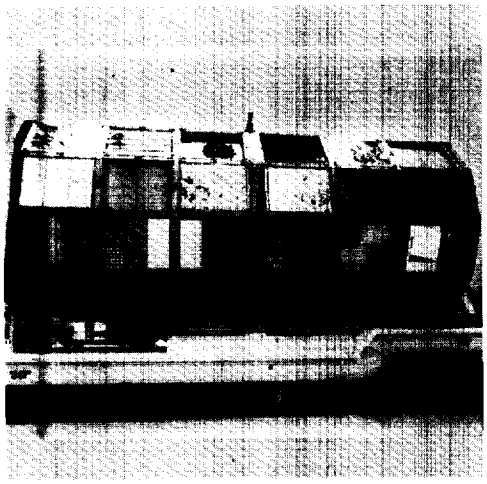

Figure 12
Photo No.: KSC-384C-419.41
Dup. Neg. No.: L84-07261
LISAR No.: EL-1994-00588
Photo Credit: KSC
Location: In SAEF II at KSC
Subject: Experiments Installed in Bays A Through F in Rows 10, 11, 12, and 1

***Figure 13 (Preflight).*** A preflight photograph, which was taken of the LDEF on the LATS, provides a view of the space end of the LDEF after experiment installation.

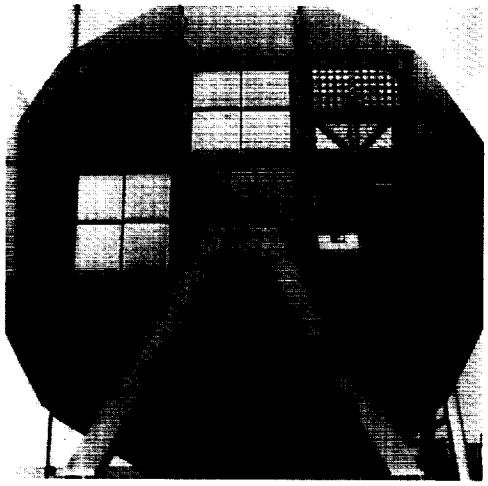

Figure 13
Photo No.: KSC-384C-419.47
Dup. Neg. No.: L84-07267
LISAR No.: EL-1994-00589
Photo Credit: KSC
Location: In SAEF II at KSC
Subject: Space End of LDEF With Experiments Installed

***Figure 14 (Preflight).*** In this photograph, the LDEF and the Solar Max Repair Module are being inserted into the cargo bay of the Space Shuttle at the launch pad.

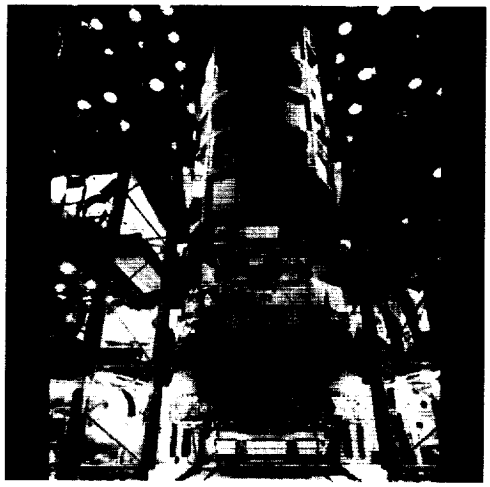

Figure 14
Photo No.: Unknown
Dup. Neg. No.: L89-07465
LISAR No.: EL-1994-00326
Photo Credit: KSC
Location: KSC Launch Pad
Subject: LDEF and Solar Max Repair Module Insertion Into Cargo Bay

***Figure 15 (Preflight).*** The *Challenger* lifted off on mission STS 41-C in April 1984. During this mission, the LDEF was deployed and the Solar Max satellite was retrieved, repaired, and redeployed.

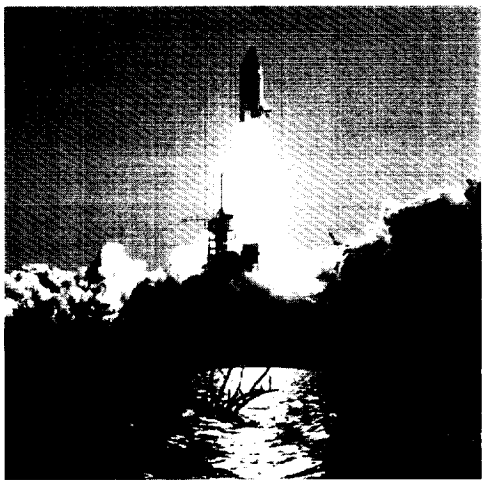

Figure 15
Photo No.: Unknown
Dup. Neg. No.: L84-05648
LISAR No.: EL-1994-00475
Photo Credit: KSC
Location: KSC Launch Pad
Subject: Liftoff of *Challenger*

***Figure 16 (In Flight).*** In this photograph, the *Challenger* is passing over Florida. The LDEF is on the RMS in preparation for deployment, which occurred approximately three-quarters of an orbit later.

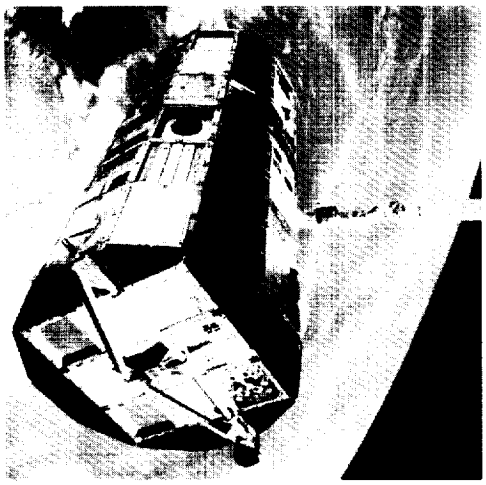

Figure 16
Photo No.: Unknown
Dup. Neg. No.: L84-04323
LISAR No.: EL-1994-00474
Photo Credit: JSC
Location: In Flight
Subject: LDEF on RMS

***Figure 17 (In Flight).*** This photograph shows the LDEF after it was deployed above the sunlit ocean and the clouds north of Hawaii.

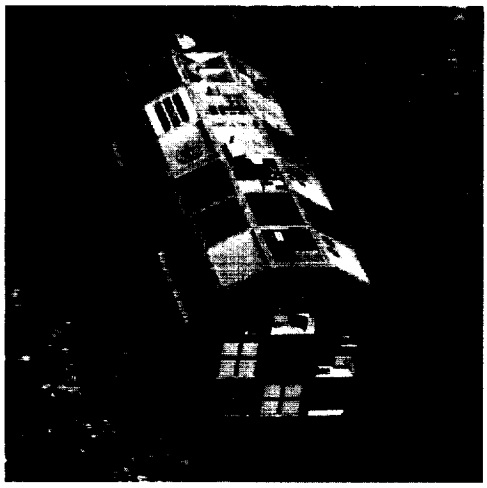

Figure 17
Photo No.: Unknown
Dup. Neg. No.: L84-04319
LISAR No.: EL-1994-00473
Photo Credit: JSC
Location: In Flight
Subject: LDEF After Deployment

***Figure 18 (Postflight).*** The *Challenger* is shown as it touched down on the dry lake bed at Edwards Air Force Base, California. This touch down ended the STS 41-C mission to deploy the LDEF and to retrieve, repair, and redeploy the Solar Max satellite.

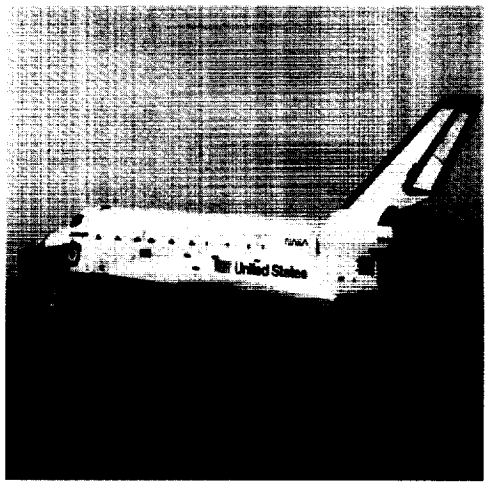

Figure 18
Photo No.: Unknown
Dup. Neg. No.: L84-04312
LISAR No.: EL-1994-00718
Photo Credit: JSC
Location: Edwards Air Force Base, Calif.
Subject: Touchdown of *Challenger*

## Retrieval of LDEF

***Figure 19 (Preflight).*** The Space Shuttle *Columbia* is shown lifting off from launch pad 39-A on January 9, 1990 on the STS 32 mission to deploy SYNCOM IV-5 and to retrieve the LDEF.

Figure 19
Photo No.: Unknown
Dup. Neg. No.: L90-13199
LISAR No.: EL-1994-00476
Photo Credit: KSC
Location: KSC Launch Pad
Subject: Liftoff of *Columbia*

***Figure 20 (In Flight).*** This photograph shows the LDEF from a view approaching the velocity vector at a range of approximately 590 ft. This view of the LDEF looks into row 9 and shows the leading edge and an oblique view of the Earth-facing end.

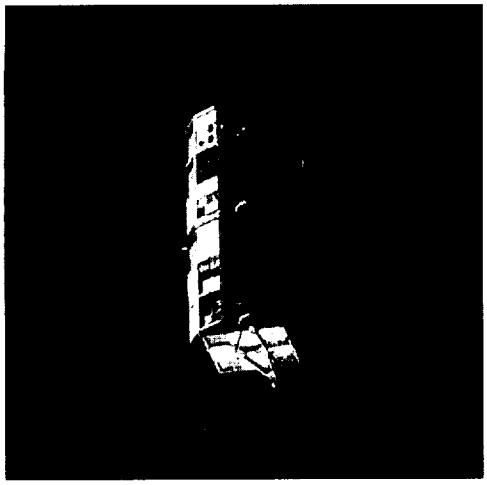

Figure 20
Photo No.: S32-77-006
Dup. Neg. No.: L90-10402
LISAR No.: EL-1994-00082
Photo Credit: JSC
Photo Date: 1/12/90
Location: In Flight
Subject: View of LDEF from *Columbia*

***Figure 21 (In Flight).*** A solar cell array, which was dislodged from experiment tray A8, is shown as it flies in formation with the LDEF.

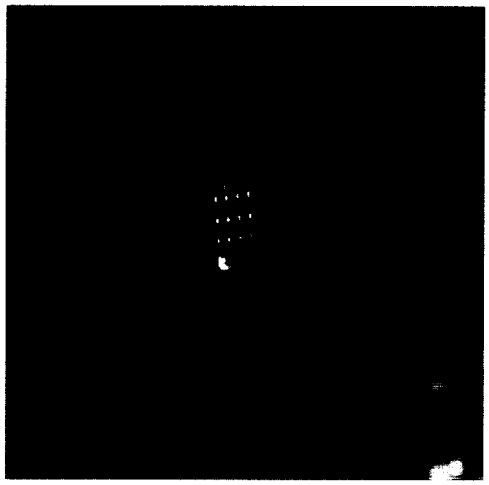

Figure 21
Photo No.: S32-77-017
Dup. Neg. No.: L90-10403
LISAR No.: EL-1994-00083
Photo Credit: JSC
Photo Date: 1/12/90
Location: In Flight
Subject: Solar Cell Array From Tray A8

***Figure 22 (In Flight).*** This figure shows the space end of the LDEF as *Columbia* descended with the RMS poised to complete the capture maneuver. The Earth and clouds are in the background. Note the extensive damage to the thermal covers of experiment M0001. The aft flight deck window frame obscures an area along the left side of the photograph.

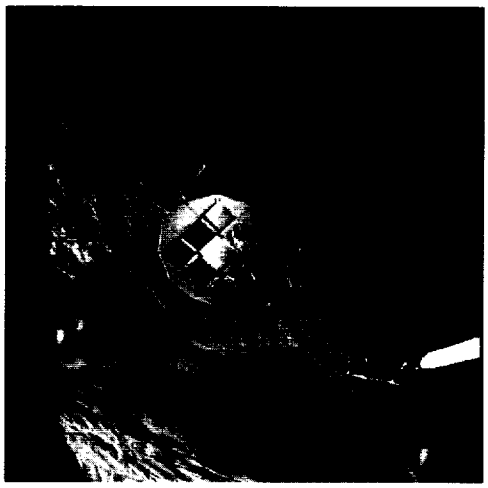

Figure 22
Photo No.: S32-85-008
Dup. Neg. No.: L90-10468
LISAR No.: EL-1994-00102
Photo Credit: JSC
Photo Date: 1/12/90
Location: In Flight
Subject: Capture of LDEF

***Figure 23 (In Flight).*** Here we see bays A through F in rows 1 through 5 with the LDEF on the RMS and the Earth in the background.

Figure 23
Photo No.: S32-85-039
Dup. Neg. No.: L90-10475
LISAR No.: EL-1994-00107
Photo Credit: JSC
Photo Date: 1/12/90
Location: In Flight
Subject: Bays A Through F in Rows 1 Through 5 With Earth in Background

***Figure 24 (In Flight).*** This view shows the space end of the LDEF during berthing in the cargo bay of the orbiter with the RMS. Note the damage to the thermal covers of the experiment M0001 and the prominent brown discolorations on other experiment hardware.

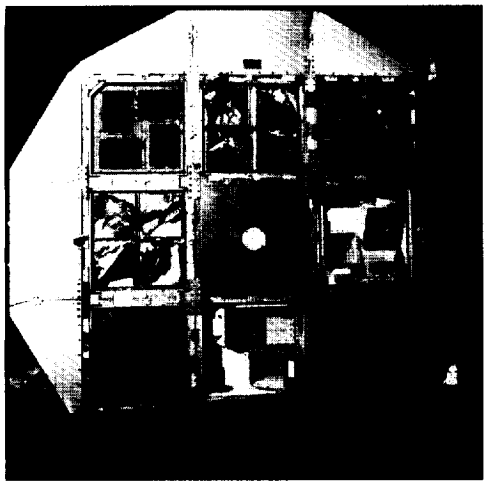

Figure 24
Photo No.: S32-82-060
Dup. Neg. No.: L90-10466
LISAR No.: EL-1994-00101
Photo Credit: JSC
Photo Date: 1/12/90
Location: In Flight
Subject: LDEF With Space End in Foreground During Berthing in Cargo Bay

***Figure 25 (In Flight).*** This oblique view is of the LDEF on the RMS with the space end in the foreground. Note the damaged thermal covers of experiment M0001. The orbiter vertical stabilizer and one of the orbiter maneuvering system (OMS) pods are in the left of the photograph.

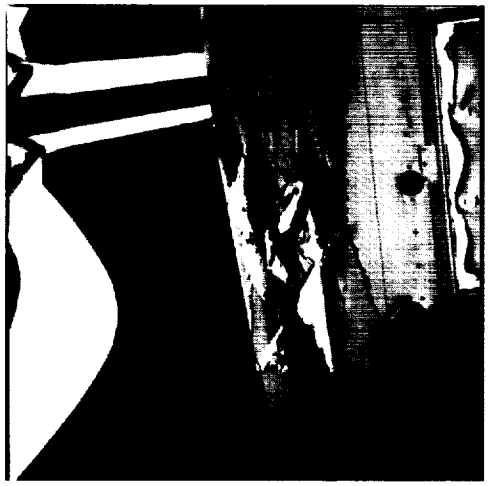

Figure 25
Photo No.: S32-77-041
Dup. Neg. No.: L90-10410
LISAR No.: EL-1994-00084
Photo Credit: JSC
Photo Date: 1/12/90
Location: In Flight
Subject: LDEF on RMS With Space End in Foreground

***Figure 26 (In Flight).*** This view shows the Earth-facing end of the LDEF on the RMS with the cloud cover of the Earth as background. Note the brown discolorations on several of the painted surfaces of the experiments. The orbiter, in the lower left corner of the photograph, is in the shadow of the LDEF. There is a shadow of the RMS across the left portion of the photograph.

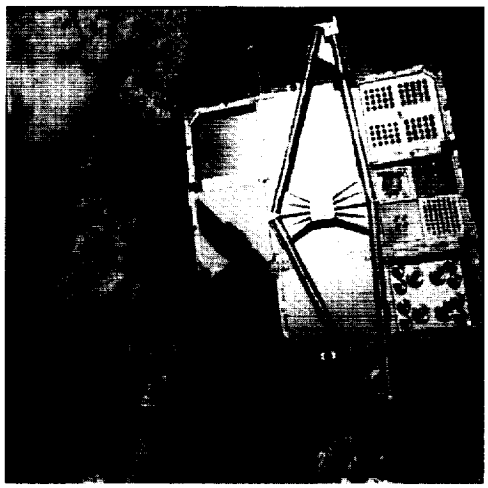

Figure 26
Photo No.: S32-85-081
Dup. Neg. No.: L90-10488
LISAR No.: EL-1994-00126
Photo Credit: JSC
Photo Date: 1/12/90
Location: In Flight
Subject: LDEF on RMS With Earth End in Foreground

***Figure 27 (In Flight).*** This view shows bays A through F in rows 1 through 5 with the LDEF on the RMS. The cloud cover over the Earth is in the background. Part of the space end is obscured by a reflection of the cargo bay liner in the window and the frame of the window itself. The reflection of the sky and clouds is visible in tray D1, which is near the RMS grapple fixture.

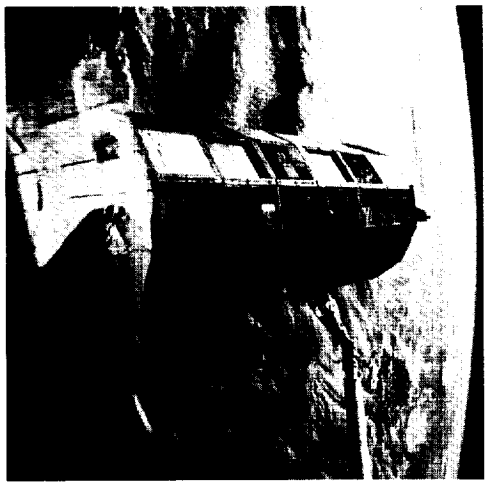

Figure 27
Photo No.: S32-75-014
Dup. Neg. No.: L90-10349
LISAR No.: EL-1994-00079
Photo Credit: JSC
Photo Date: 1/12/90
Location: In Flight
Subject: LDEF on RMS Showing Bays A Through F in Rows 1 Through 5

***Figure 28 (In Flight).*** This close-up side view shows bays A through E in rows 2 through 5 with the LDEF on the RMS. Direct sun and reflections caused some experiment details in row 4 to be washed out, while low light levels caused a lack of detail in other rows. Wrinkles in the thermal screens in tray B3 are prominent. The thermal covers of trays of experiment AO178 in row 5 show reflections of the Earth and the sky.

Figure 28
Photo No.: S32-75-008
Dup. Neg. No.: L90-10348
LISAR No.: EL-1994-00078
Photo Credit: JSC
Photo Date: 1/12/90
Location: In Flight
Subject: Close-up of LDEF on RMS Showing Bays A Through E in Rows 2 Through 5

***Figure 29 (In Flight).*** This side view shows trays in bays A through E in rows 3 through 6 with the LDEF on the RMS and the Earth in the background. The dark shading in the left side of the photograph is the outline of the aft flight deck window of the orbiter. Reflections of the blue sky and the clouds are evident in the silvered Teflon thermal covers of the experiment AO178. Note that lighting conditions and sky reflections caused rows 3 and 4 to be more blue.

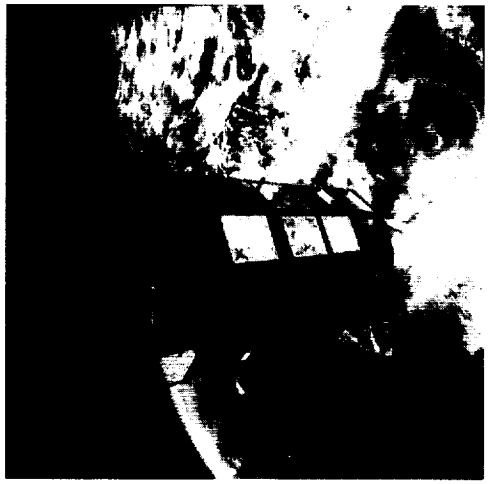

Figure 29
Photo No.: S32-85-012
Dup. Neg. No.: L90-10469
LISAR No.: EL-1994-00103
Photo Credit: JSC
Photo Date: 1/12/90
Location: In Flight
Subject: LDEF on RMS Showing Bays A Through E in Rows 3 Through 6

***Figure 30 (In Flight).*** This side view shows bays D through F in rows 3 through 6 with the LDEF on the RMS just above the cargo bay of the orbiter. The Earth and horizon are visible in the background. Reflections of the sky and the clouds in the thermal covers of experiment AO178 were somewhat subdued. A reflection of the horizon is visible in the surface of the sensors in tray E3. The photograph has a blue tint; this is probably because of light that came from the sky below.

Figure 30
Photo No.: S32-85-017
Dup. Neg. No.: L90-10470
LISAR No.: EL-1994-00104
Photo Credit: JSC
Photo Date: 1/12/90
Location: In Flight
Subject: LDEF on RMS Showing Bays D Through F in Rows 3 Through 6

***Figure 31 (In Flight).*** This side view shows bays B and C in rows 3 through 7 with the LDEF on the RMS. The bright pink tint along the left side, and to a lesser degree on the photograph in general, is a reflection of the cargo bay liner in the viewing window. Reflections in the thermal covers of experiment AO178 are visible.

Figure 31
Photo No.: S32-75-003
Dup. Neg. No.: L90-10347
LISAR No.: EL-1994-00057
Photo Credit: JSC
Photo Date: 1/12/90
Location: In Flight
Subject: Close-up of LDEF on RMS Showing Bays B and C in Rows 3 Through 7

***Figure 32 (In Flight).*** A side view shows bays A through D in rows 2 through 6 with the LDEF on the RMS and the Earth in the background. The frame of the aft flight deck window of the orbiter is visible along the left side of the photograph. Reflections of the sky are visible in the thermal covers of experiment AO178.

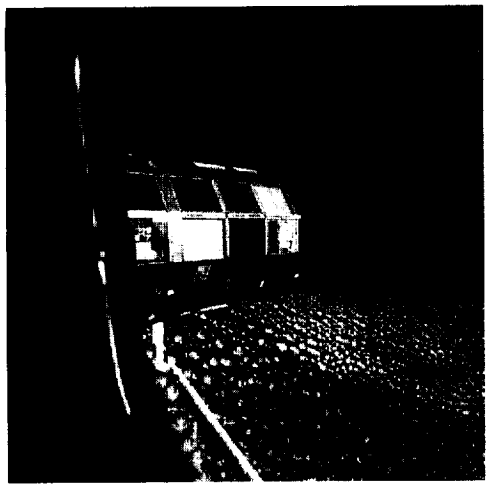

Figure 32
Photo No.: S32-85-025
Dup. Neg. No.: L90-10471
LISAR No.: EL-1994-00105
Photo Credit: JSC
Photo Date: 1/12/90
Location: In Flight
Subject: LDEF on RMS Showing Bays A Through D in Rows 2 Through 6

***Figure 33 (In Flight).*** This figure is a side view of bays C through F in rows 2 through 6 with the LDEF on the RMS. This view of the LDEF shows the Space Shuttle passing over the west coast of southern Africa. Note the sand dunes below the RMS and also their reflection in the thermal covers of experiment AO178 in trays F2 and E2. The thermal cover attachment pads of trays C5, D5, and F4 are also visible.

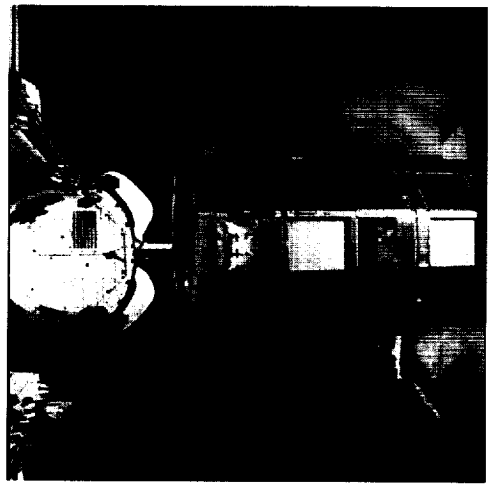

Figure 33
Photo No.: S32-85-030
Dup. Neg. No.: L90-10473
LISAR No.: EL-1994-00106
Photo Credit: JSC
Photo Date: 1/12/90
Location: In Flight
Subject: LDEF on RMS Showing Bays C Through F in Rows 2 Through 6

***Figure 34 (In Flight).*** This wide-angle view shows bays A through F in rows 11, 12, and 1 through 3 with the LDEF on the RMS against a background of the Earth and clouds. The aft flight deck window frame obscures the upper part of the photograph. Note the clean appearance of the white paint in row 12 compared with similar paint on experiment hardware in rows 2 and 3. The original bright yellow paint on the trunnion scuff plates on row 3 has darkened significantly.

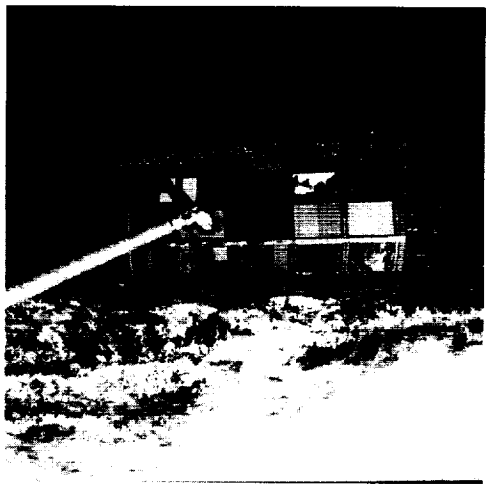

Figure 34
Photo No.: S32-85-050
Dup. Neg. No.: L90-10479
LISAR No.: EL-1994-00108
Photo Credit: JSC
Photo Date: 1/12/90
Location: In Flight
Subject: Wide-Angle View of LDEF on RMS Showing Bays A Through F in Rows 11, 12, and 1 Through 3

***Figure 35 (In Flight).*** This side view shows bays C through F in rows 11, 12, and 1 through 3 with the LDEF on the RMS. The aft flight deck window frame forms a shadow on the left edge of the photograph. The Earth with a cloud cover provides the background. Note the clean appearance of the white paint on the thermal covers in row 12 when compared with similar paint on the hardware in rows 2 and 3. The white paint dots on the experiment tray clamp blocks on row 12 appear clean; however, the dots darken progressively as row 3 is approached. The original bright yellow paint on the trunnion scuff plates on row 3 has darkened significantly.

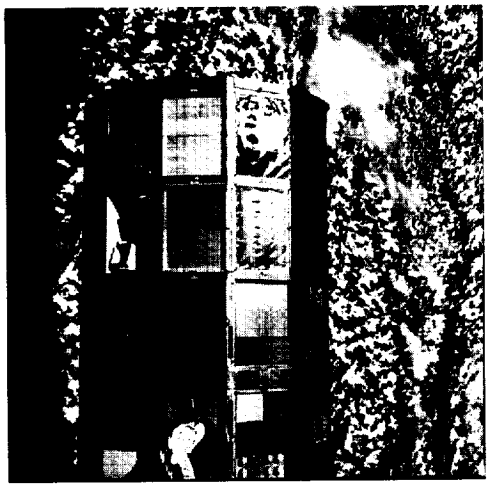

Figure 35
Photo No.: S32-85-054
Dup. Neg. No.: L90-10480
LISAR No.: EL-1994-00109
Photo Credit: JSC
Photo Date: 1/12/90
Location: In Flight
Subject: LDEF on RMS Showing Bays C Through F in Rows 11, 12, and 1 Through 3

***Figure 36 (In Flight).*** This side view shows bays A through D in rows 11, 12, and 1 through 3 with the LDEF on the RMS. The aft flight deck window frame forms a shadow on the left edge of the photograph and the Earth with a cloud cover provides the background. Note the clean appearance of the white paint on the thermal covers in row 12 when compared with similar paint on experiment hardware in rows 2 and 3. The original bright yellow paint on the trunnion scuff plates on row 3 has darkened significantly.

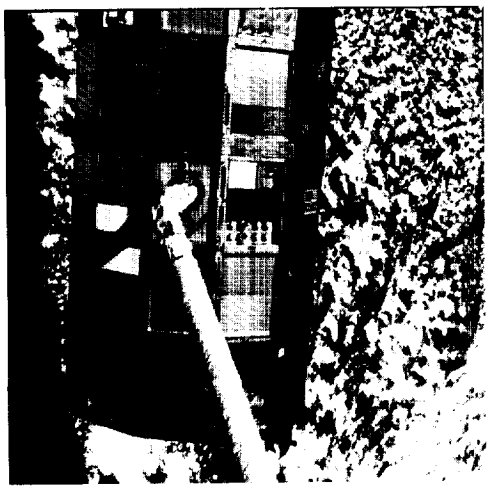

Figure 36
Photo No. S32-85-056
Dup. Neg. No.: L90-10481
LISAR No.: EL-1994-00110
Photo Credit: JSC
Photo Date: 1/12/90
Location: In Flight
Subject: LDEF on RMS Showing Bays A Through D in Rows 11, 12, and 1 Through 3

***Figure 37 (In Flight).*** This figure shows a side view of bays A through F in rows 9 through 12 and 1 with the LDEF on the RMS. The orbiter vertical stabilizer protrudes from the left edge of the photograph. The right side of the photograph is obscured by the frame of the aft flight deck window. The peculiar light pattern in the trays in row 11 and the variations along the row indicate that the cargo bay lights were on.

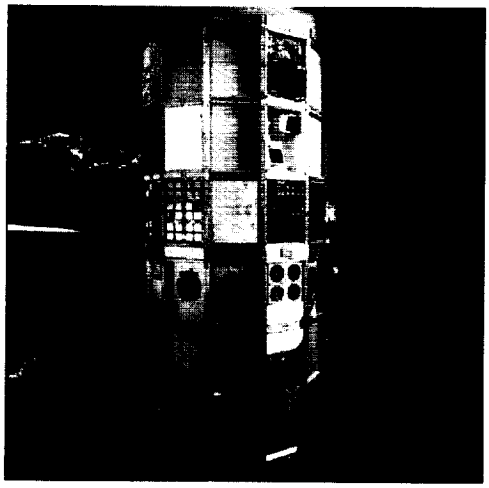

Figure 37
Photo No.: S32-85-060
Dup. Neg. No.: L90-10482
LISAR No.: EL-1994-00111
Photo Credit: JSC
Photo Date: 1/12/90
Location: In Flight
Subject: LDEF on RMS Showing Bays A Through F in Rows 9 Through 12 and 1

***Figure 38 (In Flight).*** This view shows bays A through F in rows 8 through 12 with the LDEF on the RMS. The cargo bay of the orbiter is on the left side of the photograph. Either sunlight reflected from the cargo bay or cargo bay lights illuminate rows 8 and 9.

Figure 38
Photo No.: S32-85-064
Dup. Neg. No.: L90-10483
LISAR No.: EL-1994-00125
Photo Credit: JSC
Photo Date: 1/12/90
Location: In Flight
Subject: LDEF on RMS Showing Bays A Through F in Rows 8 Through 12

***Figure 39 (In Flight).*** This view shows bays A through F in rows 4 through 7 with the LDEF on the RMS. The orbiter is in the left of the photograph and the Earth with a cloud cover is visible in the background. The reflections of the sky and clouds are visible in the thermal covers of the trays of experiment AO178.

Figure 39
Photo No.: S32-85-091
Dup. Neg. No.: L90-10489
LISAR No.: EL-1994-00127
Photo Credit: JSC
Photo Date: 1/12/90
Location: In Flight
Subject: LDEF on RMS Showing Bays A Through F in Rows 4 Through 7

***Figure 40 (In Flight).*** This side view shows bays A through C in rows 4 through 7 with the LDEF on the RMS. The bright pink in the left of the photograph is a reflection of the cargo bay liner in the viewing window. The aft flight window frame is also visible in the left of the photograph. The Earth, sky, and clouds are visible in the background. Reflections show in the thermal covers of the trays of experiment AO178. An overall blue tint was probably caused by reflections of the sky below.

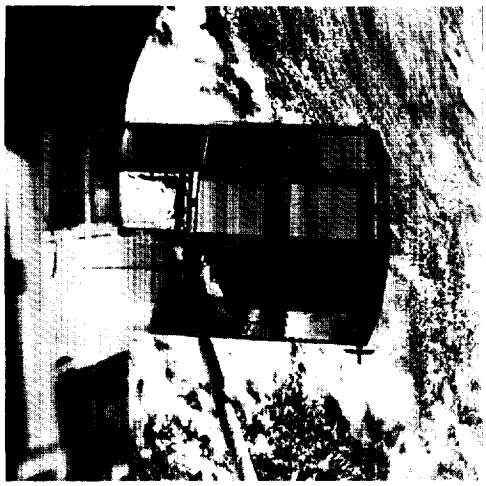

Figure 40
Photo No.: S32-85-093
Dup. Neg. No.: L90-10490
LISAR No.: EL-1994-00092
Photo Credit: JSC
Photo Date: 1/12/90
Location: In Flight
Subject: LDEF on RMS Showing Bays A Through C in Rows 4 Through 7

***Figure 41 (In Flight).*** This side view shows bays C through F in rows 4 through 7 with the LDEF on the RMS. The cargo bay of the orbiter is visible in the left of the photograph and the Earth and clouds are in the background. The photograph is dark because of the very shallow lighting angle. Reflections of the clouds and the sky are evident in the thermal covers of the trays of experiment AO178.

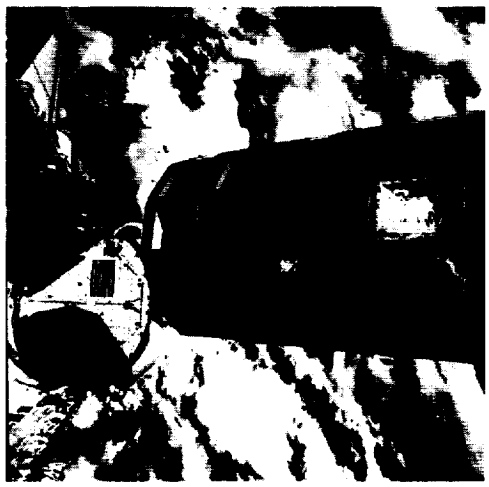

Figure 41
Photo No.: S32-85-097
Dup. Neg. No.: L90-10491
LISAR No.: EL-1994-00136
Photo Credit: JSC
Photo Date: 1/12/90
Location: In Flight
Subject: LDEF on RMS Showing Bays C Through F in Rows 4 Through 7

***Figure 42 (Postflight).*** With the LDEF onboard, the *Columbia* touched down in the predawn hours of Jan. 20, 1990 on the runway at Edwards Air Force Base, California.

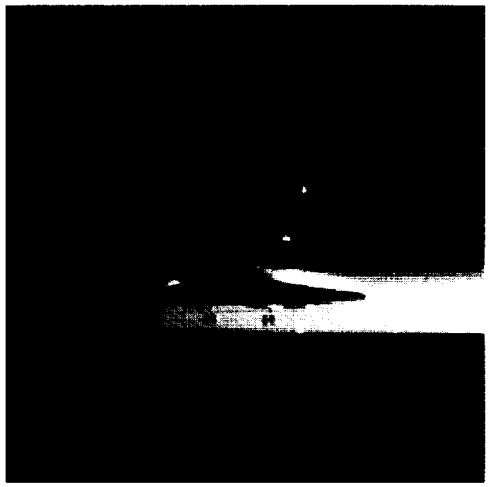

Figure 42
Photo No.: Unknown
Dup. Neg. No.: L90-13200
LISAR No.: EL-1994-00720
Photo Credit: JSC
Photo Date: 1/20/90
Location: Edwards Air Force Base, California
Subject: Landing of *Columbia*

## Removal of LDEF From Cargo Bay of Shuttle

***Figure 43 (Postflight).*** This view of the space end of the LDEF was taken from the cargo bay access hatch after the *Columbia* landed at Edwards Air Force Base, California. The cargo bay liner is visible in the bottom of the photograph. The radiators, which are located on the inside of the orbiter payload bay doors, are visible in the top. The three yellow balls on the aluminum support rods (whiskers) that are fixed in the cargo bay were used for berthing the LDEF during retrieval operations. A brown discoloration appears to be spread over the surface of the space end of the LDEF. This discoloration appears to be lighter on the anodized aluminum thermal panel surfaces and darker on the experiment surfaces that were coated with the Chemglaze A276 white thermal control paint. The discoloration on the uncoated aluminum hardware (such as the end frame splice plates) is also darker. The amber and red reflectors seem to have little apparent degradation.

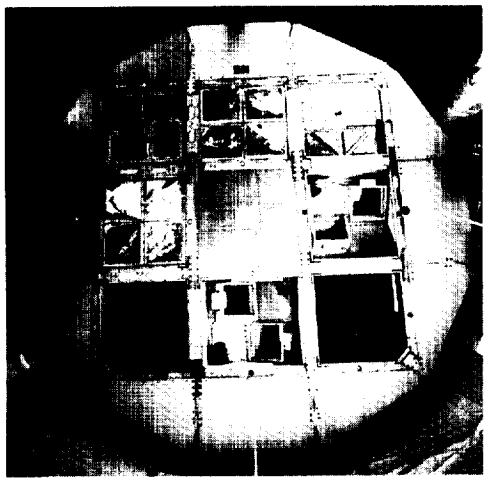

Figure 43
Photo No.: S32(S)-294
Dup. Neg. No.: L92-21201
LISAR No.: EL-1994-00100
Photo Credit: JSC
Photo Date: 1/22/90
Location: Dryden
Subject: Space End of LDEF Viewed From Cargo Bay Hatch

***Figure 44 (Postflight).*** In this figure, the orbiter payload bay doors are being opened, thus allowing the first look at the LDEF at the OPF at KSC.

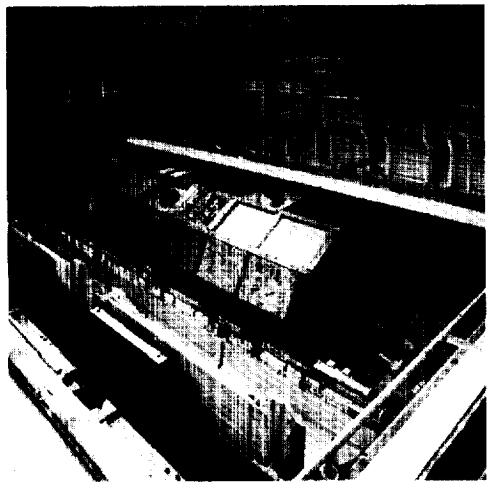

Figure 44
Photo No.: L90-1082
LISAR No.: EL-1994-00303
Photo Credit: LaRC
Photo Date: 1/30/90
Location: KSC OPF
Subject: Opening of Orbiter Payload Bay Doors

***Figure 45 (Postflight).*** The LDEF has been lifted from the orbiter payload bay in preparation for transfer to the payload canister. The payload canister with the LDEF inside was then moved to the O & C building.

Figure 45
Photo No.: L90-1087
LISAR No.: EL-1994-00323
Photo Credit: LaRC
Photo Date: 1/30/90
Location: KSC OPF
Subject: Removal of LDEF From Orbiter

***Figure 46 (Postflight).*** This postflight view is of the space end of the LDEF in the SAEF II. The discoloration in the areas of trays H6 and H9 (containing experiment AO038) and the damage to the thermal covers of experiment M0001 in trays H3 and H12 are evident. Note that the thermal panel below tray H6 has been removed.

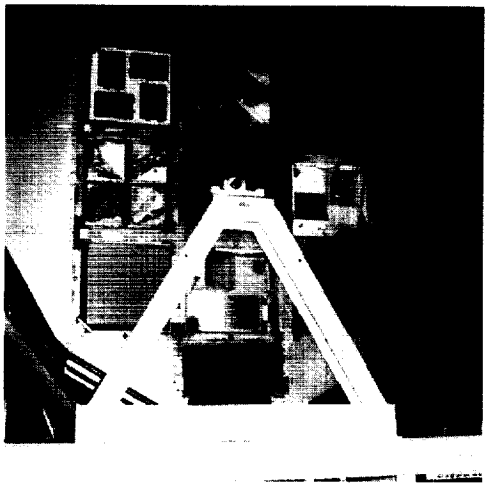

Figure 46
Photo No.: L90-1778
LISAR No.: EL-1994-00477
Photo Credit: LaRC
Location: KSC SAEF II
Subject: Postflight View of Space End of LDEF

***Figure 47 (Postflight).*** This postflight view is of the Earth end of the LDEF in the SAEF II. Some discoloration of the thermal panels on the left side of the photograph is visible. This area was affected by the end support beam in flight, which was removed when this photograph was made. The canister on the stand adjacent to tray G8 was part of the instrumentation setup for radiation measurements.

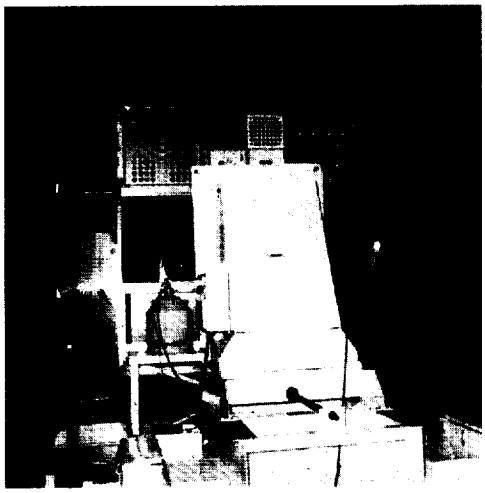

Figure 47
Photo No.: KSC-390C-833.05
Dup. Neg. No.: L90-13364
LISAR No.: EL-1994-00715
Photo Credit: KSC
Photo Date: 2/7/90
Location: KSC SAEF II
Subject: Postflight View of Earth End of LDEF

***Figure 48 (Postflight).*** This postflight view is of the LDEF in the SAEF II prior to the removal of the experiment trays. Bays A through C in rows 12 and 1 through 3 are visible.

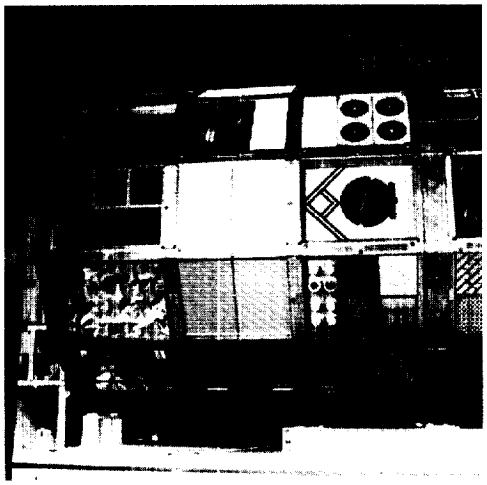

Figure 48
Photo No.: KSC-390C-1065.08
Dup. Neg. No.: L90-13465
LISAR No.: EL-1994-00114
Photo Credit: KSC
Photo Date: 2/8/90
Location: KSC SAEF II
Subject: Postflight View of Bays A Through C in Rows 12 and 1 Through 3 Prior to Removal

***Figure 49 (Postflight).*** This postflight view is of the LDEF in the SAEF II prior to removal of the experiment trays. Bays D through F in rows 12 and 1 through 3 are visible.

Figure 49
Photo No.: KSC-390C-1065.09
Dup. Neg. No.: L90-13466
LISAR No.: EL-1994-00149
Photo Credit: KSC
Photo Date: 2/8/90
Location: KSC SAEF II
Subject: Postflight View of Bays D Through F in Rows 12 and 1 Through 3 Prior to Removal of Experiments

***Figure 50 (Postflight).*** This postflight view is of the LDEF in the SAEF II prior to removal of the experiment trays. Bays A through C in rows 2 through 5 are visible.

Figure 50
Photo No.: KSC-390C-1065.04
Dup. Neg. No.: L90-13461
LISAR No.: EL-1994-00112
Photo Credit: KSC
Photo Date: 2/8/90
Location: KSC SAEF II
Subject: Postflight View of Bays A Through C in Rows 2 Through 5 Prior to Removal of Experiments

***Figure 51 (Postflight).*** This postflight view is of the LDEF in the SAEF II prior to removal of the experiment trays. Bays D through F in rows 2 through 5 are visible.

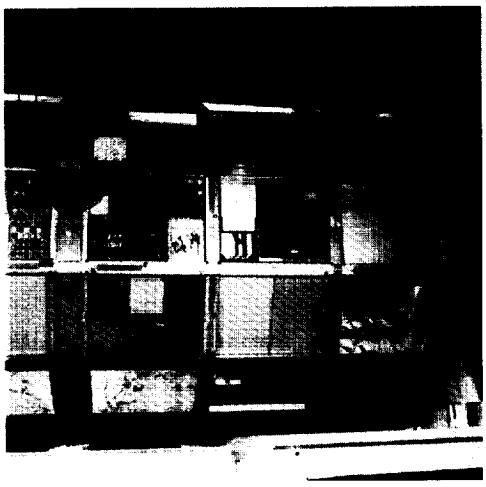

Figure 51
Photo No.: KSC-390C-1065.05
Dup. Neg. No.: L90-13462
LISAR No.: EL-1994-00113
Photo Credit: KSC
Photo Date: 2/8/90
Location: KSC SAEF II
Subject: Postflight View of Bays D Through F in Rows 2 Through 5 Prior to Removal of Experiments

***Figure 52 (Postflight).*** This postflight view is of the LDEF in the SAEF II prior to removal of the experiment trays. Bays A through C in rows 4 through 7 are visible.

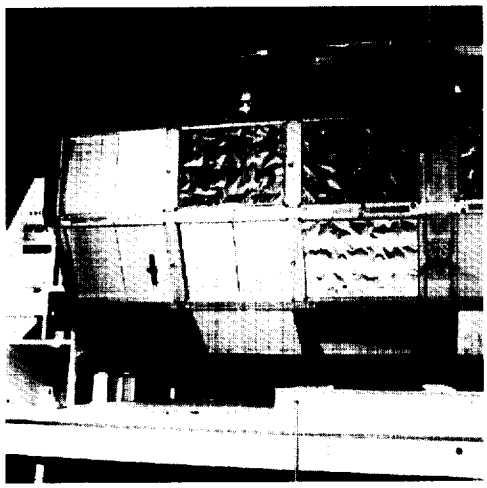

Figure 52
Photo No.: KSC-390C-1033.02
Dup. Neg. No.: L90-13434
LISAR No.: EL-1994-00304
Photo Credit: KSC
Photo Date: 2/9/90
Location: KSC SAEF II
Subject: Postflight View of Bays A Through C in Rows 4 Through 7 Prior to Removal of Experiments

***Figure 53 (Postflight).*** This postflight view is of the LDEF in the SAEF II prior to removal of the experiment trays. Bays D through F in rows 4 through 7 are visible.

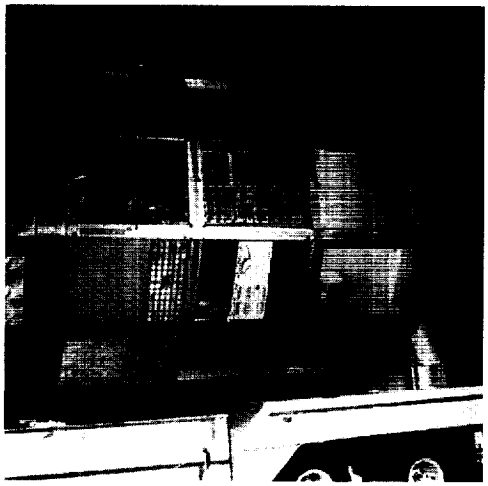

Figure 53
Photo No.: KSC-390C-1033.03
Dup. Neg. No.: L90-13435
LISAR No.: EL-1994-00305
Photo Credit: KSC
Photo Date: 2/9/90
Location: KSC SAEF II
Subject: Postflight View of Bays D Through F in Rows 4 Through 7 Prior to Removal of Experiments

***Figure 54 (Postflight).*** This postflight view is of the LDEF in the SAEF II prior to removal of the experiment trays. Bays A through C in rows 6 through 9 are visible.

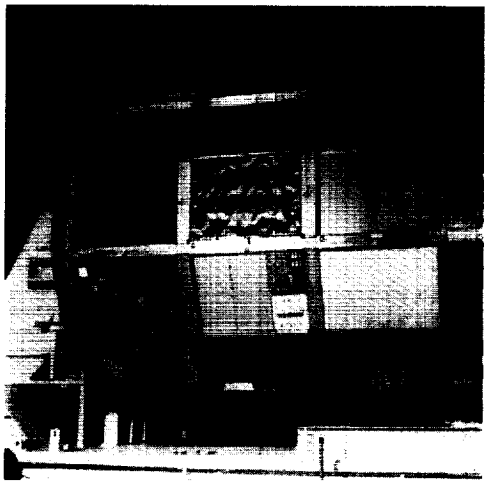

Figure 54
Photo No.: KSC-390C-1031.04
Dup. Neg. No.: L90-13414
LISAR No.: EL-1994-00289
Photo Credit: KSC
Photo Date: 2/9/90
Location: KSC SAEF II
Subject: Postflight View of Bays A Through C in Rows 6 Through 9 Prior to Removal of Experiments

***Figure 55 (Postflight).*** This postflight view is the LDEF in the SAEF II prior to removal of the experiment trays. Bays D through F in rows 6 through 9 are visible.

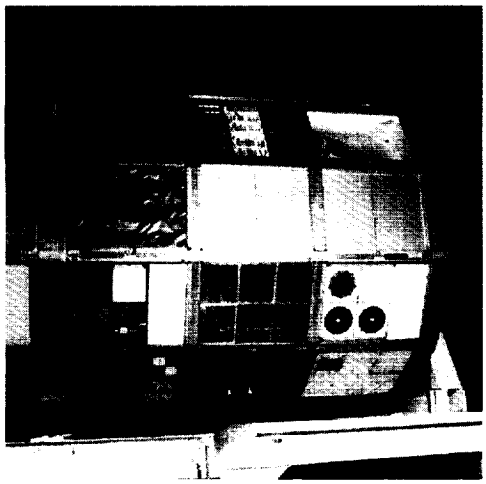

Figure 55
Photo No.: KSC-390C-1031.05
Dup. Neg. No.: L90-13415
LISAR No.: EL-1994-00290
Photo Credit: KSC
Photo Date: 2/9/90
Location: KSC SAEF II
Subject: Postflight View of Bays D Through F in Rows 6 Through 9 Prior to Removal of Experiments

***Figure 56 (Postflight).*** This postflight view is of the LDEF in the SAEF II prior to removal of the experiment trays. Bays A through C in rows 8 through 11 are visible.

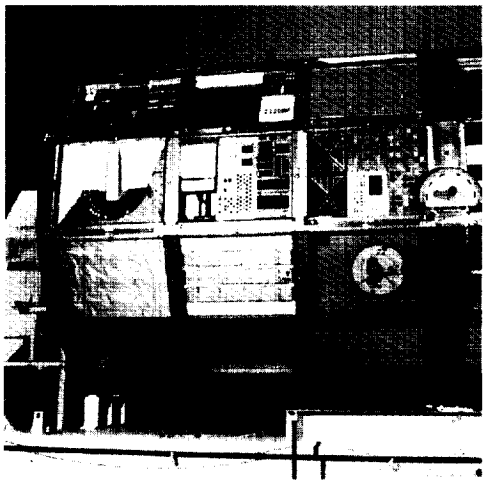

Figure 56
Photo No.: KSC-390C-1029.01
Dup. Neg. No.: L90-13387
LISAR No.: EL-1994-00287
Photo Credit: KSC
Photo Date: 2/9/90
Location: KSC SAEF II
Subject: Postflight View of Bays A Through C in Rows 8 Through 11 Prior to Removal of Experiments

***Figure 57 (Postflight).*** This postflight view is of the LDEF in the SAEF II prior to removal of the experiment trays. Bays D through F in rows 8 through 11 are visible.

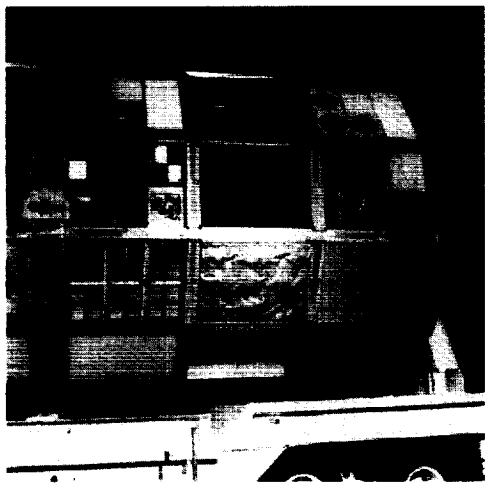

Figure 57
Photo No.: KSC-390C-1029.02
Dup. Neg. No.: L90-13388
LISAR No.: EL-1994-00288
Photo Credit: KSC
Photo Date: 2/9/90
Location: KSC SAEF II
Subject: Postflight View of Bays D Through F in Rows 8 Through 11 Prior to Removal of Experiments

***Figure 58 (Postflight).*** This postflight view is of the LDEF in the SAEF II prior to removal of the experiment trays. Bays A through C in rows 10 through 12 and 1 are visible.

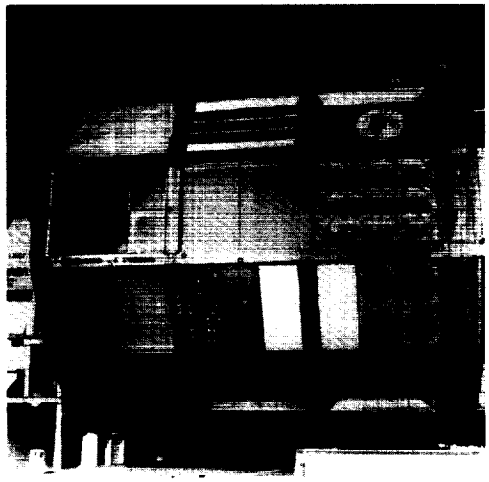

Figure 58
Photo No.: KSC-390C-1069.05
Dup. Neg. No.: L90-13485
LISAR No.: EL-1994-00150
Photo Credit: KSC
Photo Date: 2/8/90
Location: KSC SAEF II
Subject: Postflight View of Bays A Through C in Rows 10 Through 12 and 1 Prior to Removal of Experiments

***Figure 59 (Postflight).*** This postflight view is of the LDEF in the SAEF II prior to removal of the experiment trays. Bays D through F in rows 10 through 12 and 1 are visible.

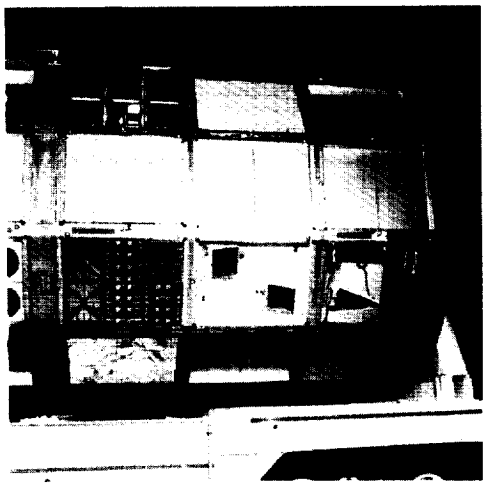

Figure 59
Photo No.: KSC-390C-1069.06
Dup. Neg. No.: L90-13486
LISAR No.: EL-1994-00063
Photo Credit: KSC
Photo Date: 2/8/90
Location: KSC SAEF II
Subject: Postflight View of Bays D Through F in Rows 10 Through 12 and 1 Prior to Removal of Experiments

***Figure 60 (Postflight).*** This postflight view is of the LDEF in the SAEF II after all experiment trays except the grapple fixture trays were removed. This oblique view is of the Earth-facing end and a side.

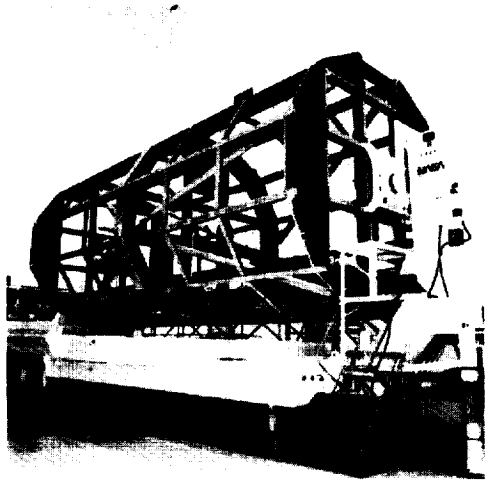

Figure 60
Photo No.: KSC-390C-2366.01
Dup. Neg. No.: L92-17916
LISAR No.: EL-1994-00698
Photo Credit: KSC
Photo Date: 3/28/90
Location: KSC SAEF II
Subject: Postflight View of Earth End of LDEF With Trays Removed

***Figure 61 (Postflight).*** This postflight view is of the LDEF in the SAEF II after all trays except the grapple fixture trays were removed. This oblique view is of the space end and a side.

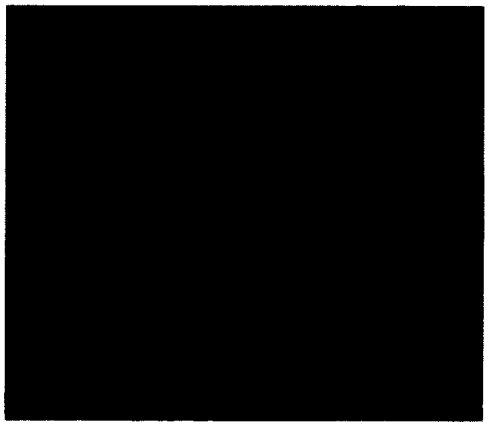

Figure 61
Photo No.: KSC-390C-2366.06
Dup. Neg. No.: L92-17921
LISAR No.: EL-1994-00699
Photo Credit: KSC
Photo Date: 3/28/90
Location: KSC SAEF II
Subject: Postflight View of Space End of LDEF With Trays Removed

***Figure 62 (Postflight).*** This view is of the magnetic damper protective shroud after removal from the LDEF. This shroud protected the damper from any particles that could be attracted by the strong magnet and affect the stability of the LDEF. Note the protective tape over the temperature sensor electrical lead.

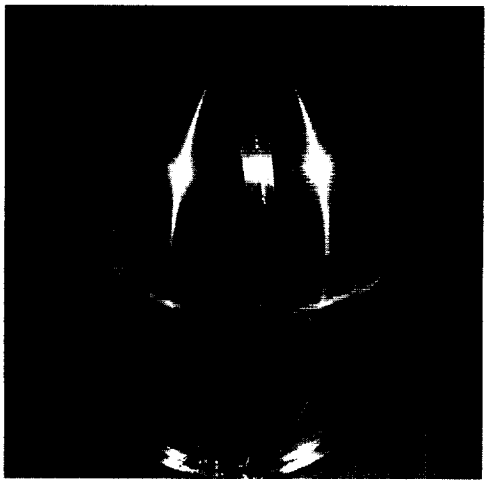

Figure 62
Photo No.: KSC-390C-3383.02
Dup. Neg. No.: L92-19010
LISAR No.: EL-1994-00700
Photo Credit: KSC
Photo Date: 4/18/90
Location: KSC SAEF II
Subject: Postflight View of Magnetic Damper Protective Shroud

***Figure 63 (Postflight).*** This photograph is of the magnetically anchored viscous damper after removal from the LDEF. The bolts that fastened the damper to the fiberglass support structure have been removed. The damper had a gold coating for thermal control in flight.

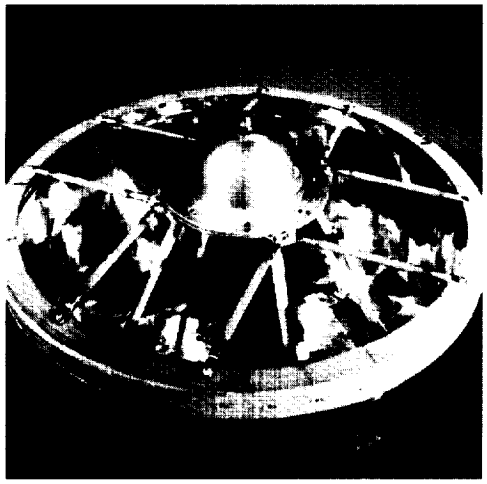

Figure 63
Photo No.: KSC-390C-3383.07
Dup. Neg. No.: L92-19015
LISAR No.: EL-1994-00701
Photo Credit: KSC
Photo Date: 4/18/90
Location: KSC SAEF II
Subject: Postflight View of Magnetic Damper After Removal From LDEF

# Photographs of Experiment Trays

## Tray A1

Evaluation of Long Duration Exposure to the Natural Space Environment on Graphite-Polyimide and Graphite-Epoxy Mechanical Properties (AO175)

Rockwell International Corp.

Trays: A1 and A7

The objective of this passive experiment was the accumulation of operational data from exposure of graphite-polyimide and graphite-epoxy material to the space environment.

***Figure 64 (Preflight).*** This photograph shows a graphite-epoxy honeycomb panel in the lower half of the tray, a graphite-epoxy panel in the upper right section, and two graphite-polyimide panels (one in the upper center and one in the upper left).

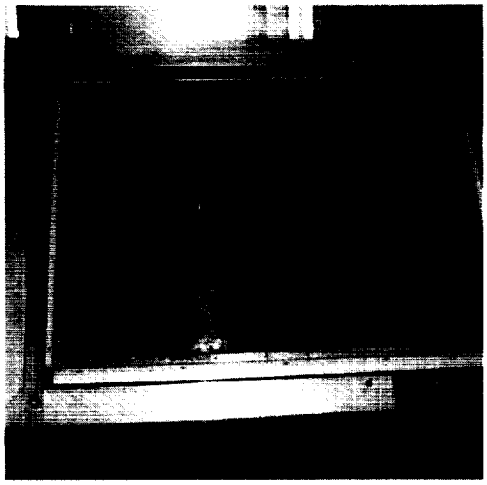

Figure 64
Photo No.: KSC-384C-221.01
Dup. Neg. No.: L84-7083
LISAR No.: EL-1994-00369
Photo Credit: KSC
Photo Date: 1/13/84
Location: KSC SAEF II
Subject: Preflight Survey Panel Position in Tray A1

***Figure 65 (In Flight).*** The test panel discoloration pattern visible in the prelaunch photograph remained unchanged. The identification numbers on all panels changed to a light brown. The ripple patterns on the polyimide panels were the result of manufacturing techniques and were not caused by exposure to space.

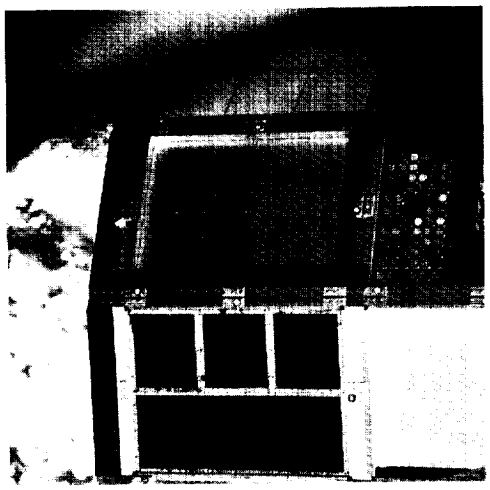

Figure 65
Photo No.: S32-78-029
Dup. Neg. No.: L90-10430
LISAR No.: EL-1994-00006
Photo Credit: JSC
Photo Date: 1/12/90
Location: In Flight
Subject: In-Flight Survey of Panels in Tray A1

***Figure 66 (Postflight).*** This photograph shows considerably more detail than the in-flight photograph. The horizontal lines on the honeycomb panel that appear to be cracks from space exposure are fine lines of excess epoxy resin that were formed during the manufacturing bagging and curing process. The harsh white of the epoxy adhesive along the rivet lines is from the lighting conditions in the OPF. The greater detail shows that a stain exists at most composite and mounting strip interfaces.

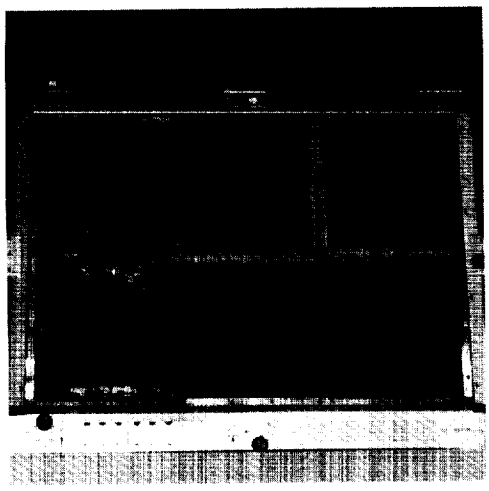

Figure 66
Photo No.: KSC-390C-609.02
Dup. Neg. No.: L92-17828
LISAR No.: EL-1994-00119
Photo Credit: KSC
Photo Date: 1/30/90
Location: KSC OPF
Subject: Postflight Survey of Panels in Tray A1

***Figure 67 (Postflight).*** This close-up photograph of the upper left one-sixth of the tray shows the ripple pattern in the polyimide panel. The brown discolorations on the aluminum retaining strips are prominent.

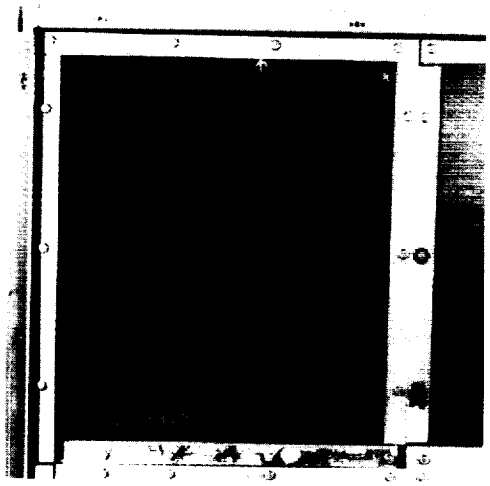

Figure 67
Photo No.: KSC-390C-2148.06
Dup. Neg. No.: L91-2891
LISAR No.: EL-1994-00511
Photo Credit: KSC
Photo Date: 3/21/90
Location: KSC SAEF II
Subject: Postflight Detail of Polyimide Panel in Tray A1

***Figure 68 (Postflight).*** This close-up photograph of the upper center one-sixth of the tray shows the ripple and the texture pattern of the polyimide test panel. The discoloration at the retaining strip and the test panel interface is visible.

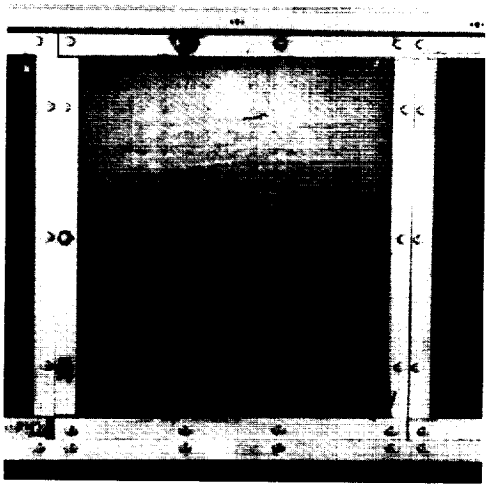

Figure 68
Photo No.: KSC-390C-2148.07
Dup. Neg. No.: L91-2892
LISAR No.: EL-1994-00512
Photo Credit: KSC
Photo Date: 3/21/90
Location: KSC SAEF II
Subject: Postflight Detail of Polyimide Panel in Tray A1

***Figure 69 (Postflight).*** This close-up photograph of the upper right one-sixth of the tray shows the honeycomb pattern in the graphite-epoxy test panel. Light reflections caused the right side, especially the lower section, of the panel to be somewhat lighter than the rest of the panel. Discoloration spots on the aluminum retaining strips are visible.

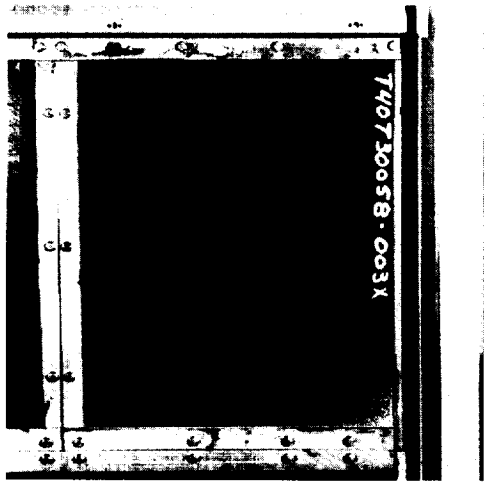

Figure 69
Photo No.: KSC-390C-2148.08
Dup. Neg. No.: L91-2893
LISAR No.: EL-1994-00591
Photo Credit: KSC
Photo Date: 3/21/90
Location: KSC SAEF II
Subject: Postflight Detail of Graphite-Epoxy Panel in Tray A1

***Figure 70 (Postflight).*** This close-up photograph of the lower left one-sixth of the tray shows a portion of the graphite-epoxy test panel. The lighter spots around the upper and lower edges are the result of repairs that were made to the test panels after manufacture and are not due to any effects of the space exposure. The honeycomb pattern of the panel structure is visible.

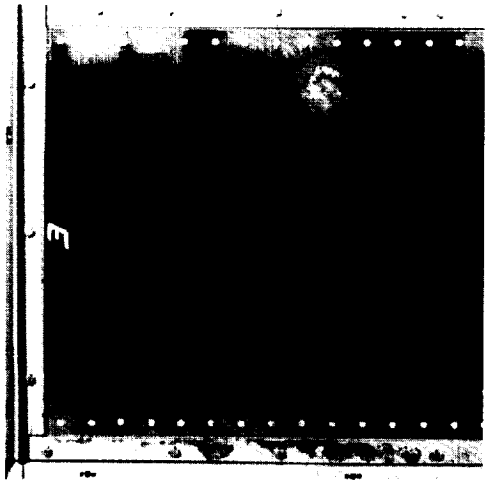

Figure 70
Photo No.: KSC-390C-2148.09
Dup. Neg. No.: L91-2894
LISAR No.: EL-1994-00592
Photo Credit: KSC
Photo Date: 3/21/90
Location: KSC SAEF II
Subject: Postflight Detail of Graphite-Epoxy Panel in Tray A1

***Figure 71 (Postflight).*** This close-up photograph of the lower center one-sixth of the tray shows the center portion of the graphite-epoxy test panel. The light spots around the upper and the lower edges are the result of repairs that were made to the test panels after manufacture and are not due to any effects of space exposure. The honeycomb pattern of the panel structure is particularly visible in these spots.

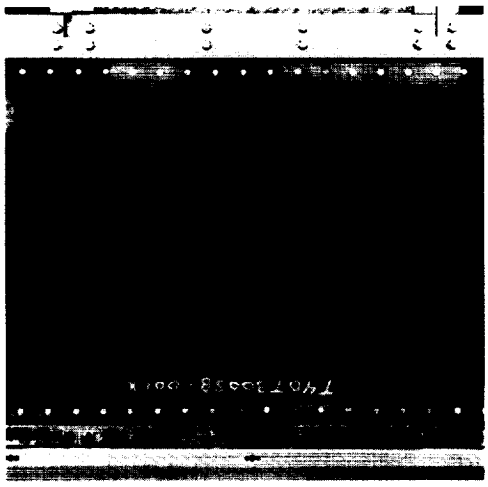

Figure 71
Photo No.: KSC-390C-2148.10
Dup. Neg. No.: L91-2895
LISAR No.: EL-1994-00593
Photo Credit: KSC
Photo Date: 3/21/90
Location: KSC SAEF II
Subject: Postflight Detail of Graphite-Epoxy Panel in Tray A1

***Figure 72 (Postflight).*** This close-up photograph of the lower right one-sixth of the tray shows the right portion of the graphite-epoxy test panel. The light spots around the edges are the result of repairs that were made to the test panels after manufacture and are not due to space exposure. The honeycomb pattern of the panel structure is particularly visible around these spots.

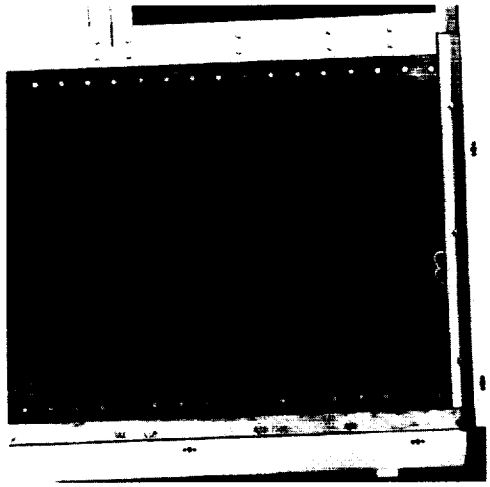

Figure 72
Photo No.: KSC-390C-2148.11
Dup. Neg. No.: L91-2896
LISAR No.: EL-1994-00706
Photo Credit: KSC
Photo Date: 3/21/90
Location: KSC SAEF II
Subject: Postflight Detail of Graphite-Epoxy Test Panel in Tray A1

## Tray A2

A High-Resolution Study of Ultraheavy Cosmic Ray Nuclei (UHCRE) (AO178)

Dublin Institute for Advanced Studies

ESA at ESTEC

Trays: A2, A4, A10, B5, B7, C5, C6, C8, C11, D1, D5, D7, D11, E2, E10, and F4

See section entitled "Tray D5" and figure 319 for a typical preflight photograph of experiment AO178.

***Figure 73 (In Flight).*** In this photograph, tray A2 is located in the lower row. The thermal cover is without visible damage; however, it is more taut than in the prelaunch photograph. The wrinkled spots on the thermal cover are over areas where Velcro pads are bonded to the back of the cover. The rippled effect around the cover edges occurs between the attachment pads.

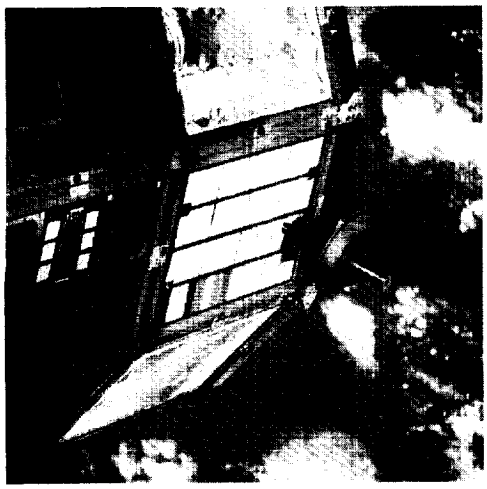

Figure 73
Photo No.: S32-77-055
Dup. Neg. No.: L90-10414
LISAR No.: EL-1994-00680
Photo Credit: JSC
Photo Date: 1/12/90
Location: In Flight
Subject: In-Flight Survey of Tray A2

***Figure 74 (Postflight).*** The thermal cover appears to be specular and undamaged. It is less taut than in the in-flight photograph. The uniformly located oval spots on the thermal cover are areas where Velcro pads attach the thermal cover to the support frame; these spots are more visible than in the prelaunch photograph. The scallop effect around the cover edges occurs between the attachment pads and shows the upper edge of the support frame. The ground strap appears to be in place with no visible damage, although it is darker.

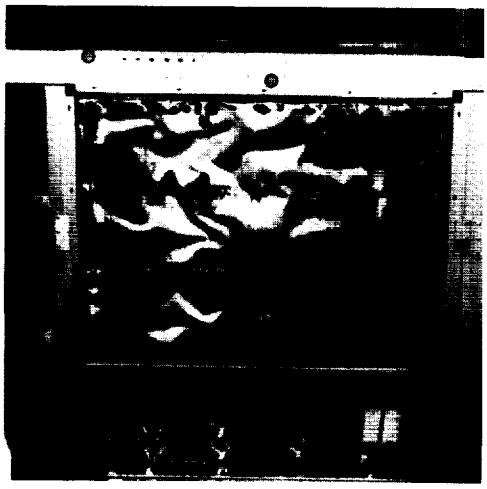

Figure 74
Photo No.: KSC-390C-1066.06
Dup. Neg.: L90-13475
LISAR No.: EL-1994-00387
Photo Credit: KSC
Photo Date: 2/8/90
Location: KSC SAEF II
Subject: Postflight Survey of Thermal Cover of Tray A2

***Figure 75 (Postflight).*** This close-up photograph of the upper left one-sixth of the tray shows a faint pattern of marks similar to brush marks in a top-to-bottom direction. This pattern is somewhat less specular than other regions. Observation of this tray during operations in the OPF and later in the SAEF II showed less specular areas on the thermal cover. Some fingerprints on the thermal cover are visible. The reflective properties of the uneven surface of the cover result in various light and color patterns.

Figure 75
Photo. No.: KSC-390C-2333.10
Dup. Neg. No.: L91-2906
LISAR No.: EL-1994-00596
Photo Credit: KSC
Photo Date: 3/27/90
Location: KSC SAEF II
Subject: Postflight Detail of Upper Left of Thermal Cover of Tray A2

***Figure 76 (Postflight).*** This close-up photograph of the upper center one-sixth of tray A2 shows an obvious pattern of marks similar to brush marks in a top-to-bottom direction. The pattern is less specular than in other areas. This appearance was present in observations in OPF and SAEF II operations. The reflective properties of the uneven surface of the cover result in various light and color patterns.

Figure 76
Photo No.: KSC-390C-2333.11
Dup. Neg. No.: L91-2907
LISAR No.: EL-1994-00597
Photo Credit: KSC
Photo Date: 3/27/90
Location: KSC SAEF II
Subject: Postflight Detail of Upper Center of Thermal Cover of Tray A2

***Figure 77 (Postflight).*** This close-up photograph of the upper right one-sixth of tray A2 shows a faint pattern of marks similar to brush marks in a top-to-bottom direction. These marks are not as prominent as in the left portions of the tray. The reflective properties of the uneven surface of the cover result in various light and color patterns.

Figure 77
Photo No.: KSC-390C-2333.12
Dup. Neg. No.: L91-2908
LISAR No.: EL-1994-00598
Photo Credit: KSC
Photo Date: 3/27/90
Location: KSC SAEF II
Subject: Postflight Detail of Upper Right of Thermal Cover of Tray A2

***Figure 78 (Postflight).*** This close-up photograph of the lower left one-sixth of tray A2 shows a pattern of marks similar to brush marks in a top-to-bottom direction. The light area in the upper right is a reflection of photographic lights. The reflective properties of the uneven surface of the cover result in various light and color patterns.

Figure 78
Photo No.: KSC-390C-2334.05
Dup. Neg. No.: L91-2913
LISAR No.: EL-1994-00599
Photo Credit: KSC
Photo Date: 3/27/90
Location: KSC SAEF II
Subject: Postflight Detail of Lower Left of Thermal Cover of Tray A2

***Figure 79 (Postflight).*** This close-up photograph of the lower center one-sixth of tray A2 has a bright area in the upper part of the frame that is caused by light reflections. The lower portions are somewhat darker because of lighting. The reflective properties of the uneven surface of the cover result in various light and color patterns.

Figure 79
Photo No.: KSC-390C-2334.06
Dup. Neg. No.: L91-2914
LISAR No.: EL-1994-00600
Photo Credit: KSC
Photo Date: 3/27/90
Location: KSC SAEF II
Subject: Postflight Detail of Lower Center of Thermal Cover of Tray A2

***Figure 80 (Postflight).*** This close-up photograph of the lower right one-sixth of tray A2 is somewhat dark because of lighting. The reflective properties of the uneven surface of the cover result in various light and color patterns.

Figure 80
Photo No.: KSC-390C-2334.07
Dup. Neg.: L91-2915
LISAR No.: EL-1994-00601
Photo Credit: KSC
Photo Date: 3/27/90
Location: KSC SAEF II
Subject: Postflight Detail of Lower Right of Thermal Cover of Tray A2

## Tray A3

The Chemistry of Micrometeoroids (AO187-1)

NASA JSC

University of Washington

Rockwell International Science Center

Trays: A3 and A11

The objective of this experiment was to retrieve analyzable projectile residue associated with hypervelocity craters.

***Figure 81 (Preflight).*** This prelaunch photograph shows two clamshell canisters in closed positions. The canisters house collector surfaces made of 99.99-percent-pure gold sheets that are 0.5-mm thick. Other smaller samples of Al (99.999-percent pure), Ti (99.9-percent pure), Be (99.9-percent pure), Zr (99.8-percent pure), C (99.999-percent pure), Kapton film (a polyimide), and Teflon filters were also exposed.

Figure 81
Photo No.: KSC-384C-300.06
Dup. Neg. No.: L84-7366
LISAR No.: EL-1994-00200
Photo Credit: KSC
Photo Date: 1/20/84
Location: KSC SAEF II
Subject: Preflight Survey of Canisters in Closed Positions in Tray A3

***Figure 82 (In Flight).*** The canisters are shown in open positions in the center tray of bay A. They were expected to open about 2 weeks after launch and close about 11 months into the mission. All exposed materials are secure and no damage is evident. Contamination stain coats the tray flanges and the aluminum canister hardware. The end support beam scuff plate in the photograph was a bright yellow prior to launch, but it is now a much darker mustard yellow after space exposure.

Figure 82
Photo No.: S32-77-055
Dup. Neg. No.: L90-10414
LISAR No.: EL-1994-00680
Photo Credit: JSC
Photo Date: 1/12/90
Location: In Flight
Subject: In-Flight Survey of Tray A3

***Figure 83 (Postflight).*** The experiment is shown in the postflight configuration before the canisters were closed with ground support equipment that bypassed the onboard electronic circuits. There is no visible damage. The reflection of a video camera on a tripod and light sources are visible in the surfaces of the gold foil.

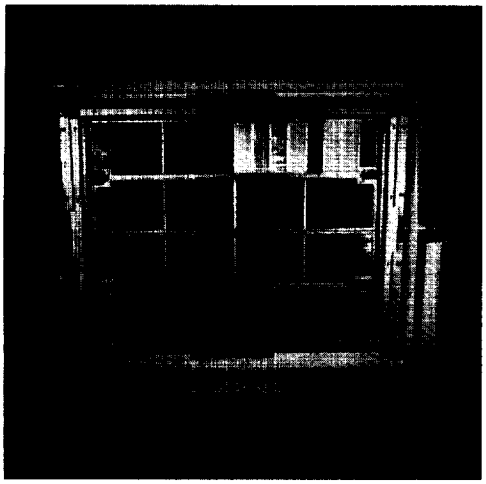

Figure 83
Photo No.: KSC-390C-1764.10
Dup. Neg.: L91-7553
LISAR No.: EL-1994-00266
Photo Credit: KSC
Photo Date: 3/9/90
Location: KSC SAEF II
Subject: Postflight Survey of Tray A3

***Figure 84 (Postflight).*** The experiment canisters are shown after being closed by ground support equipment. The experiment hardware has no damage.

Figure 84
Photo No.: KSC-390C-1843.08
Dup. Neg. No.: L91-7590
LISAR No.: EL-1994-00280
Photo Credit: KSC
Photo Date: 3/12/90
Location: KSC SAEF II
Subject: Postflight Survey of Closed Canisters in Tray A3

***Figure 85 (Postflight).*** This photograph of the upper left one-fourth of the tray shows light and room reflections in the gold foil. The foil appears to be in preflight condition.

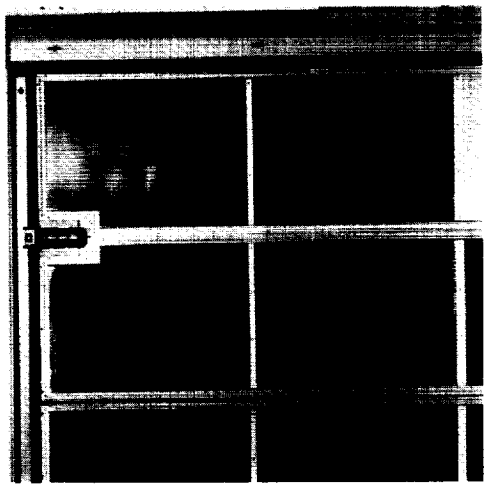

Figure 85
Photo No.: KSC-390C-1764.11
Dup. Neg. No.: L91-7554
LISAR No.: EL-1994-00247
Photo Credit: KSC
Photo Date: 3/9/90
Location: KSC SAEF II
Subject: Postflight Detail of Upper Left of Tray A3

***Figure 86 (Postflight).*** This photograph of the upper right one-fourth of the tray shows light and room reflections in the highly reflective gold foil. The foil appears to be in preflight condition. Photographic lights washed-out details of the test strips along the top of the tray.

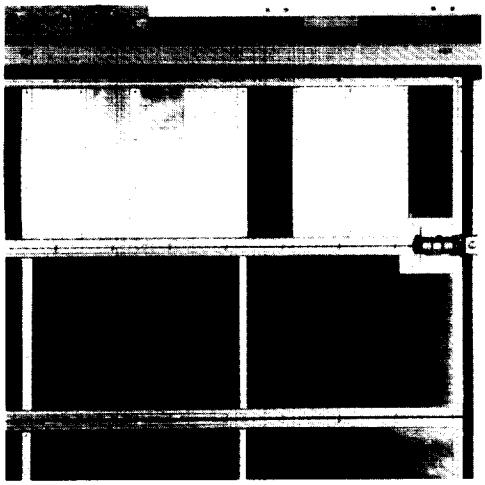

Figure 86
Photo No.: KSC-390C-1764.12
Dup. Neg. No.: L91-7555
LISAR No.: EL-1994-00248
Photo Credit: KSC
Photo Date: 3/9/90
Location: KSC SAEF II
Subject: Postflight Detail of Upper Right of Tray A3

***Figure 87 (Postflight).*** This photograph of the lower left one-fourth of the tray shows light and room reflections in the highly reflective gold foil. The foil appears to be in preflight condition.

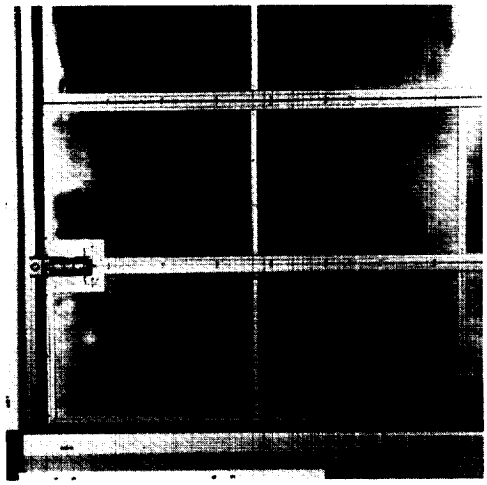

Figure 87
Photo No.: KSC-390C-1765.02
Dup. Neg. No.: L91-7557
LISAR No.: EL-1994-00249
Photo Credit: KSC
Photo Date: 3/9/90
Location: KSC SAEF II
Subject: Postflight Detail of Lower Left of Tray A3

***Figure 88 (Postflight).*** This photograph of the lower right one-fourth of the tray shows light and room reflections in the highly reflective gold foil. The green is a reflection of the clean room garments that were worn by nearby personnel. The foil appears to be in preflight condition.

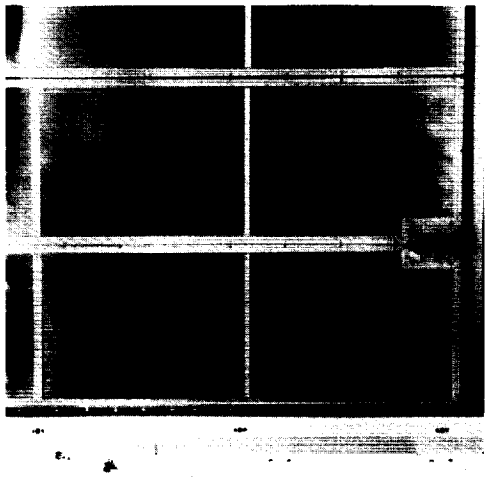

Figure 88
Photo No.: KSC-390C-1765.03
Dup. Neg. No.: L91-7558
LISAR No.: EL-1994-00250
Photo Credit: KSC
Photo Date: 3/9/90
Location: KSC SAEF II
Subject: Postflight Detail of Lower Right of Tray A3

## Tray A4

A High-Resolution Study of Ultraheavy Cosmic Ray Nuclei (UHCRE) (AO178)

Dublin Institute for Advanced Studies

ESA at ESTEC

Trays: A2, A4, A10, B5, B7, C5, C6, C8, C11, D1, D5, D7, D11, E2, E10, and F4

See section entitled "Tray D5" and figure 319 for a typical preflight photograph of experiment AO178.

***Figure 89 (In Flight).*** The thermal cover appears to be specular and undamaged, but it is more taut than in the prelaunch photograph. The wrinkled spots on the thermal cover are areas where Velcro pads are bonded to the back of the cover. The scalloped effect around the cover edges occurs between the attachment pads. The ground strap appears to be in place and to have no visible damage.

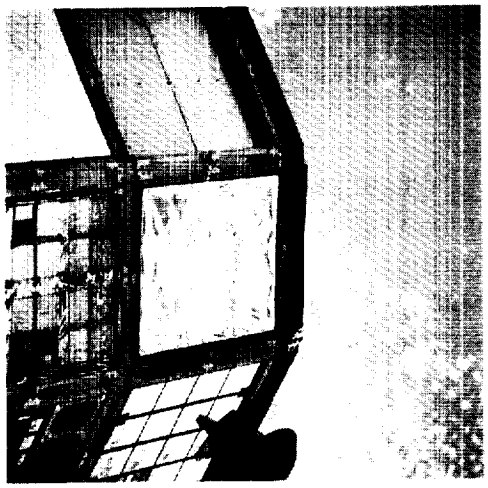

Figure 89
Photo No.: S32-77-023
Dup. Neg. No.: L90-10406
LISAR No.: EL-1994-00089
Photo Credit: JSC
Photo Date: 1/12/90
Location: In Flight
Subject: In-Flight Survey of Tray A4

***Figure 90 (Postflight).*** The thermal cover appears to be specular and undamaged. It appears less taut than in the in-flight photograph. The uniformly located oval spots on the thermal cover are areas where Velcro pads attached the thermal cover to the support frame. These attachment pads are more visible than in the prelaunch photograph. The scallop effect around the cover edges occurs between the attachment pads and shows the upper edge of the support frame. The ground strap appears to be in place with no visible damage.

Figure 90
Photo No.: KSC-390C-832.07
Dup. Neg. No.: L90-13354
LISAR No.: EL-1994-00174
Photo Credit: KSC
Photo Date: 2/7/90
Location: KSC SAEF II
Subject: Postflight Survey of Thermal Cover of Tray A4

***Figure 91 (Postflight).*** This postflight photograph was taken in SAEF II after the silvered Teflon thermal cover had been removed. All experiment hardware appears to be in prelaunch condition and to be securely in place. The three cylindrical pressure vessels that contain the experiment detectors are shown mounted in the experiment tray. The frame for mounting the thermal cover is in the foreground. The white rectangles on the frame are Velcro pads bonded to the frame for attaching the thermal cover. The Velcro pads are in excellent condition. The top half of the cylinders and the thermal cover frame were painted black to meet thermal control requirements.

Figure 91
Photo No.: KSC-390C-1761.10
Dup. Neg. No.: L91-7617
LISAR No.: EL-1994-00272
Photo Credit: KSC
Photo Date: 3/9/90
Location: KSC SAEF II
Subject: Postflight Survey of Tray A4 With Thermal Cover Removed

***Figure 92 (Postflight).*** This photograph is of the upper left one-sixth of the tray. The thermal cover appears specular and undamaged. The reflective properties of the uneven surface of the cover result in various light and color patterns. The locations of the Velcro attachment pads are obvious.

Figure 92
Photo No.: KSC-390C-1743.07
Dup. Neg. No.: L91-7611
LISAR No.: EL-1994-00240
Photo Credit: KSC
Photo Date: 3/8/90
Location: KSC SAEF II
Subject: Postflight Detail of Upper Left of Thermal Cover of Tray A4

***Figure 93 (Postflight).*** This photograph is of the upper center one-sixth of the tray. The thermal cover appears specular with no apparent damage. The reflective properties of the uneven surface of the cover result in various light and color patterns. The locations of the Velcro attachment pads are obvious.

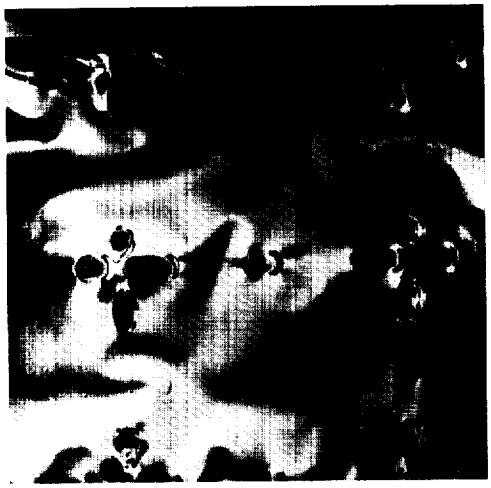

Figure 93
Photo No.: KSC-390C-1743.08
Dup. Neg. No.: L91-7612
LISAR No.: EL-1994-00241
Photo Credit: KSC
Photo Date: 3/8/90
Location: KSC SAEF II
Subject: Postflight Detail of Upper Center of Thermal Cover of Tray A4

***Figure 94 (Postflight).*** This photograph is of the upper right one-sixth of the tray. The thermal cover appears specular and undamaged. The reflective properties of the uneven surface of the cover result in various light and color patterns. The locations of the Velcro attachment pads are obvious.

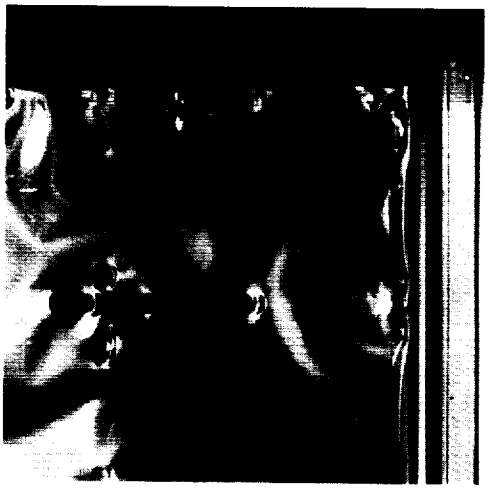

Figure 94
Photo No.: KSC-390C-1743.09
Dup. Neg. No.: L91-7613
LISAR No.: EL-1994-00243
Photo Credit: KSC
Photo Date: 3/8/90
Location: KSC SAEF II
Subject: Postflight Detail of Upper Right of Tray A4

***Figure 95 (Postflight).*** This photograph is of the lower left one-sixth of the tray. The thermal cover appears specular and undamaged. The reflective properties of the uneven surface of the cover result in various light and color patterns. The locations of the Velcro attachment pads are obvious.

Figure 95
Photo No.: KSC-390C-1743.10
Dup. Neg. No.: L91-7614
LISAR No.: EL-1994-00244
Photo Credit: KSC
Photo Date: 3/8/90
Location: KSC SAEF II
Subject: Postflight Detail of Lower Left of Tray A4

***Figure 96 (Postflight).*** This photograph is of the lower center one-sixth of the tray. The thermal cover appears specular and undamaged. The reflective properties of the uneven surface of the cover result in various light and color patterns. The locations of the Velcro attachment pads are obvious.

Figure 96
Photo No.: KSC-390C-1743.11
Dup. Neg. No.: L91-7615
LISAR No.: EL-1994-00245
Photo Credit: KSC
Photo Date: 3/8/90
Location: KSC SAEF II
Subject: Postflight Detail of Lower Center of Tray A4

***Figure 97 (Postflight).*** This photograph is of the lower right one-sixth of the tray. The thermal cover appears specular and undamaged. The reflective properties of the uneven surface of the cover result in various light and color patterns. The locations of the Velcro attachment pads are obvious.

Figure 97
Photo No.: KSC-390C-1743.12
Dup. Neg. No.: L91-7616
LISAR No.: EL-1994-00246
Photo Credit: KSC
Photo Date: 3/8/90
Location: KSC SAEF II
Subject: Postflight Detail of Lower Right of Tray A4

## Tray A5

Space Debris Impact Experiment (S0001)

NASA LaRC

Trays: A5, A6, A12, B1, B2, B6, B8, B11, C4, C7, D2, D6, E1, E4, E7, E11, F1, F3, F5, F7, F10, F11, G4, G8, and H5

The objective of this passive experiment was to determine the population, directionality, and chemical composition of natural and spacecraft orbital debris.

***Figure 98 (Preflight).*** Because trays dedicated to experiment S0001 (except tray A6, which had the target for the keel camera) were not photographed prior to flight, a spare tray was photographed for descriptive purposes. Experiment S0001 consisted of two 3/16-in-thick chromic-anodized aluminum panels that were mounted in a 3-in-deep peripheral tray. The panel had two coatings: a thin layer of chromic anodization that faced the exterior and a Chemglaze-306 black paint that faced the interior. Both coatings contributed significantly to thermal control of the LDEF. The pink and greenish-gray tints and the vertical stripes on the two debris panels were by-products of the chromic anodization coating process. The anodization appears to make surface features or markings more visible.

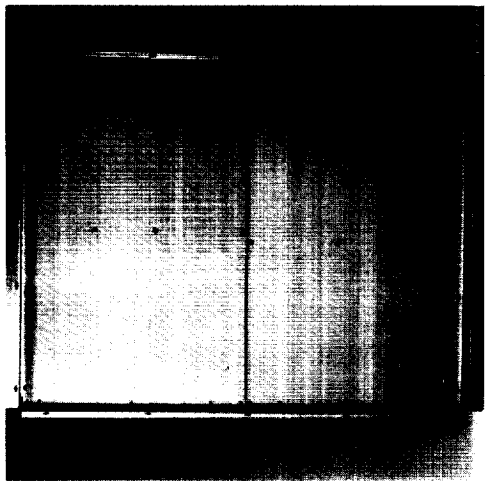

Figure 98
Photo No.: L94-6744
LISAR No.: EL-1994-00478
Photo Credit: LaRC
Photo Date: 9/27/94
Location: LaRC Photographic Studio
Subject: Preflight Survey of Spare Tray

***Figure 99 (In Flight).*** Fingerprints that were observed on the lower tray flange and the sidewall indicate the lack of proper preflight handling and cleaning. The greenish-gray and pink tints on the two debris panels are by-products of the chromic anodization coating process and are not attributed to contamination or exposure to the space environment.

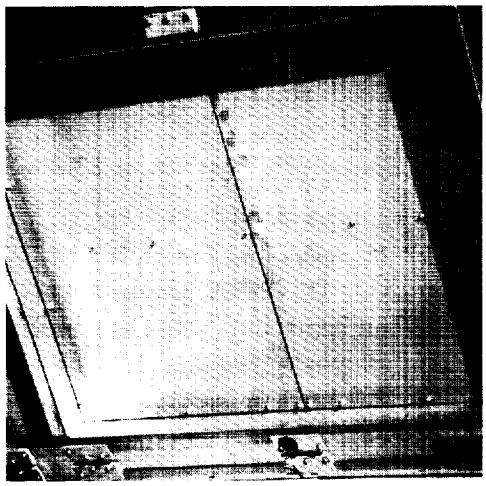

Figure 99
Photo No.: S32-76-079
Dup. Neg. No.: L90-10395
LISAR No.: EL-1994-00059
Photo Credit: JSC
Photo Date: 1/12/90
Location: In Flight
Subject: In-Flight Survey of Tray A5

***Figure 100 (Postflight).*** The greenish-gray and pink tints on the two debris panels are by-products of the chromic anodization coating process and are not attributed to contamination or exposure to the space environment. The fingerprints along the edges of the left panel that were observed in the in-flight photograph are still visible. Those visible previously along the top edges have been washed out by the lighting. The light band along the sides and across the bottom of the panels is caused by light reflecting from the tray sidewalls.

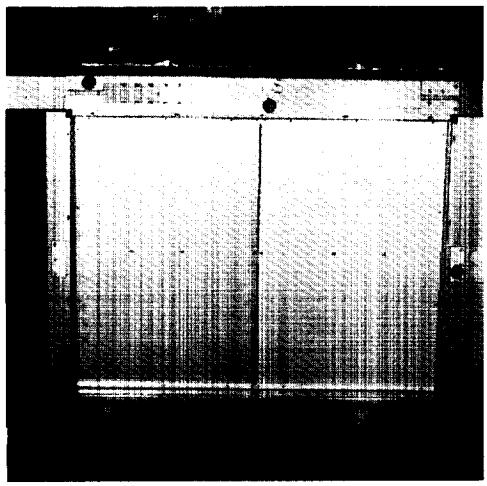

Figure 100
Photo No.: KSC-390C-1035.09
Dup. Neg.: L90-13454
LISAR No.: EL-1994-00185
Photo Credit: KSC
Photo Date: 2/9/90
Location: KSC SAEF II
Subject: Postflight Survey of Tray A5

## Tray A6

Space Debris Impact Experiment (S0001)

NASA LaRC

Trays: A5, A6, A12, B1, B2, B6, B8, B11, C4, C7, D2, D6, E1, E4, E7, E11, F1, F3, F5, F7, F10, F11, G4, G8, and H5

See section entitled "Tray A5" for a typical preflight photographic survey and experiment objective.

***Figure 101 (Preflight).*** This tray is typical of the other 18 trays dedicated to experiment S0001 except for the target for the Shuttle keel camera and the reflector. The target and the reflector were visual aids for berthing the LDEF during retrieval. This photograph of tray A6 and the photograph of the spare flight tray shown in figure 98 can be used to judge the preflight appearance of the witness plates for experiment S0001. The greenish-gray and pink tints are by-products of the chromic anodization coating process. The line pattern is due to the rolling mill operation during manufacturing. The anodization makes such surface features more visible.

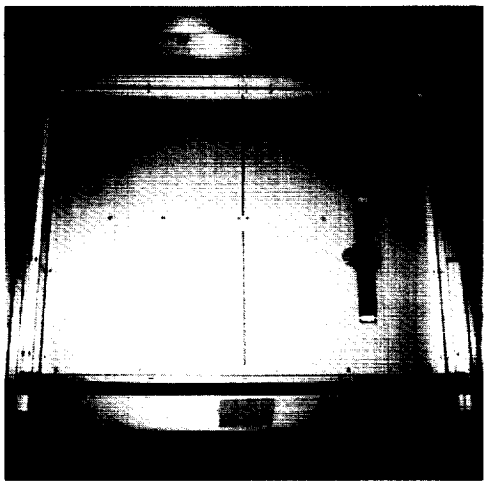

Figure 101
Photo No.: KSC-384C-372.05
Dup. Neg. No.: L84-7210
LISAR No.: EL-1994-00688
Photo Credit: KSC
Photo Date: 1/26/84
Location: KSC SAEF II
Subject: Preflight Survey of Tray A6

***Figure 102 (In Flight).*** The pink and greenish-gray tints and the horizontal stripes on the two debris panels are by-products of the chromic anodization coating process and are not attributed to exposure to the space environment. The blue is due to lighting and is not a true change in surface color. The brown irregular discolorations along the center edges of the debris panels appear to be fingerprints from prelaunch handling. The black unit located on the top panel is a target for the keel camera that was used during the berthing of the LDEF. The stripes and the tip of the vertical rod of the target for the keel camera appear darker than in the prelaunch photograph. The light band across the top panel is reflected light from the tray sidewall and the dark band down the right side of the panels is a shadow from the tray sidewall.

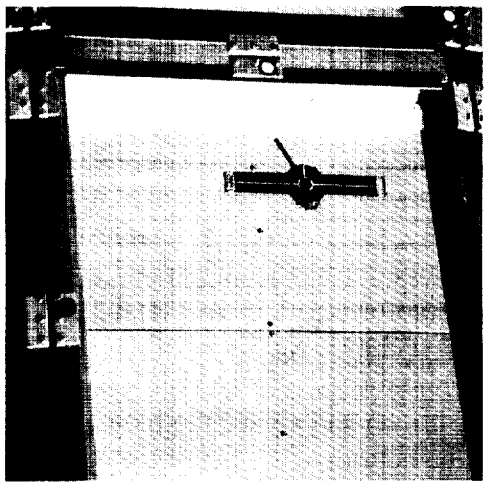

Figure 102
Photo No.: S32-76-087
Dup. Neg. No.: L90-10396
LISAR No.: EL-1994-00060
Photo Credit: JSC
Photo Date: 1/12/90
Location: In Flight
Subject: In-Flight Survey of Tray A6

***Figure 103 (Postflight).*** The pink and the greenish-gray tints on the two debris panels are by-products of the chromic anodization coating process and are not attributed to contamination or exposure to the space environment. The fingerprints along the center edges of the debris panels that were observed in the in-flight photograph are still visible. The vertical streaks on the debris panels appear to be the same as on the prelaunch photograph. The stripes and the tip of the vertical rod of the target for the keel camera appear darker than in the prelaunch photograph. The light band along the right side and across the bottom of the panels is caused by light reflecting from the tray sidewalls.

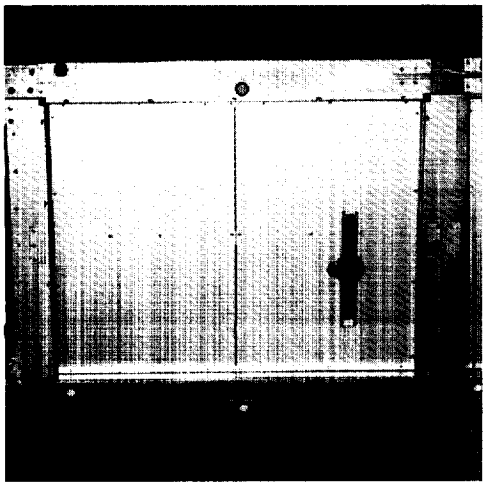

Figure 103
Photo No.: KSC-390C-1035.03
Dup. Neg. No.: L90-13448
LISAR No.: EL-1994-00181
Photo Credit: KSC
Photo Date: 2/9/90
Location: KSC SAEF II
Subject: Postflight Survey of Tray A6

## Tray A7

Evaluation of Long Duration Exposure to the Natural Space Environment on Graphite-Polyimide and Graphite-Epoxy Mechanical Properties (AO175)

Rockwell International Corp.

Trays: A1 and A7

The objective of this experiment was to accumulate operational data from the exposure of graphite-polyimide and graphite-epoxy material to the environment of space.

***Figure 104 (Preflight).*** The experiment in this tray consisted of three graphite-polyimide laminate panels and associated mounting hardware. Each panel occupied one-third of the LDEF tray: a PMR-15 precured graphite-polyimide panel (T40T30060-009) was in the right one-third section, an F-178/T300 cocured graphite-polyimide panel (T40T30060-005) was in the center one-third section, and an F-178/T300 precured graphite-polyimide panel (T40T30060-001) was in the left one-third section of the tray. Each panel was identified with yellow markings. The dull gold-colored coating has been scraped from the aluminum mounting strip near the upper left tray corner. The PMR-15 panel is a uniform dark brown. The panel has several off-white marks in the lower right corner. Light grayish-brown discolorations are visible behind the identification number and behind the off-white marks. The F178/T300 cocured panel is dark brown. The F178/300 precured panel is dark brown and appears to have a lighter brown area along the vertical center, which extends from the bottom to the top of the panel.

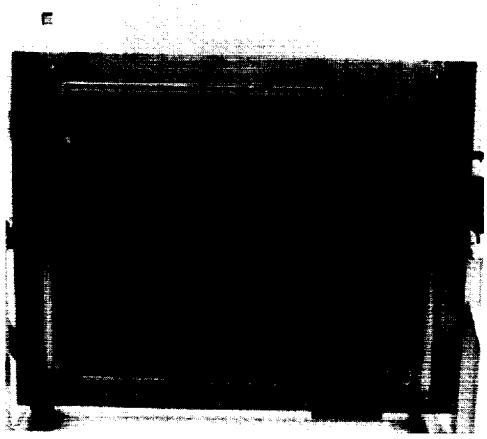

Figure 104
Photo No.: KSC-384C-209.01
Dup. Neg. No.: L84-7071
LISAR No.: EL-1994-00357
Photo Credit: KSC
Photo Date: 1/16/84
Location: KSC SAEF II
Subject: Preflight Survey of Tray A7

***Figure 105 (In Flight).*** In this photograph, the dull gold-colored coating that was observed on the aluminum mounting strips in the preflight photograph has turned to a medium brown. The yellow numbers seem darker than in prelaunch conditions, but the white markings appear the same. There seems to be fine horizontal lines, cracks, and crazing on the surface of each panel. The PMR-15 panel on the left appears to have changed from brown (at prelaunch) to light gray. A geometric pattern, probably from the laminating process, is visible on the surface. Scratch marks and abrasions on the lower left edge of panel were on the preflight photographs. The F-178/T300 cocured panel in the center seems to have changed from dark brown to light gray. The F-178/T300 precured panel on the right appears to have changed from dark brown with a lighter brown area along the vertical center to a uniform light gray.

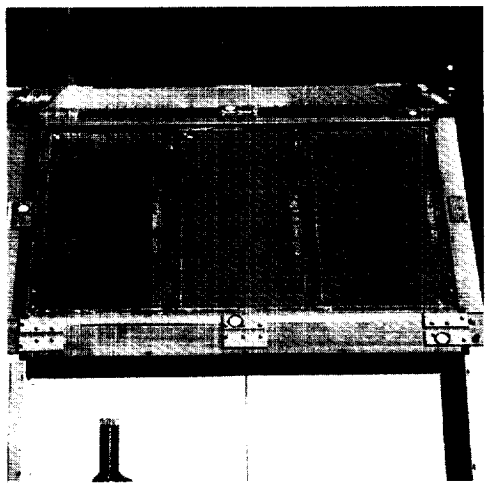

Figure 105
Photo No.: S32-76-095
Dup. Neg. No.: L90-10398
LISAR No.: EL-1994-00061
Photo Credit: JSC
Photo Date: 1/12/90
Location: In Flight
Subject: In-Flight Survey of Tray A7

***Figure 106 (Postflight).*** The areas on the aluminum mounting strips where the coating has been scraped or abraded can be seen in greater detail under the better lighting in this photograph. The coating color remains essentially the same. The yellow numbers seem to be a little lighter than in the in-flight photograph, but the white markings appear unchanged. The fine horizontal lines, cracks, and crazing are still visible on the surface of the panels. The PMR-15 panel on the left seems to have a gray haze over the gray brown surface. The scratch marks and abrasions on the lower left edge of the panel were on the preflight photographs. The geometric pattern visible in the in-flight photograph is not visible in this photograph. The F-178/T300 cocured panel in the center appears to have changed from the light gray in the in-flight photograph to a brownish gray. The F-178/T300 precured panel on the right seems to have changed to a brownish gray from the light gray visible in the in-flight photograph.

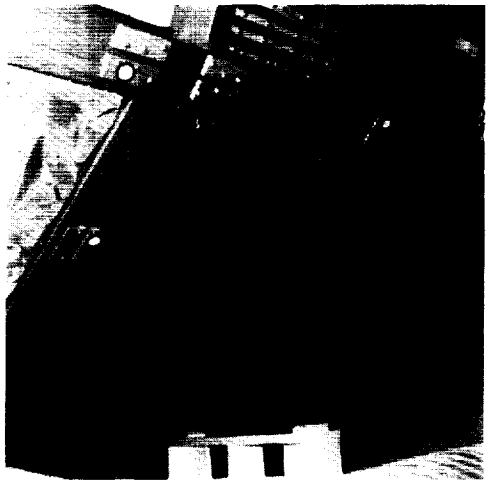

Figure 106
Photo No.: KSC-390C-725.04
Dup. Neg. No.: L92-17551
LISAR No.: EL-1994-00163
Photo Credit: KSC
Photo Date: 2/1/90
Location: KSC O & C building
Subject: Postflight Survey of Tray A7

***Figure 107 (Postflight).*** This close-up photograph is of the two left panels (F-178/T300 precured and F-178/T300 cocured). The yellow numbers appear lighter than in the in-flight photograph. The fine horizontal lines, cracks, and crazing are still visible on the panel surface. The F-178/T300 precured panel seems to have changed to a brownish gray from the light gray visible in the in-flight photograph. The F-178/T300 cocured panel appears to have changed from the light gray in the in-flight photograph to a brownish gray.

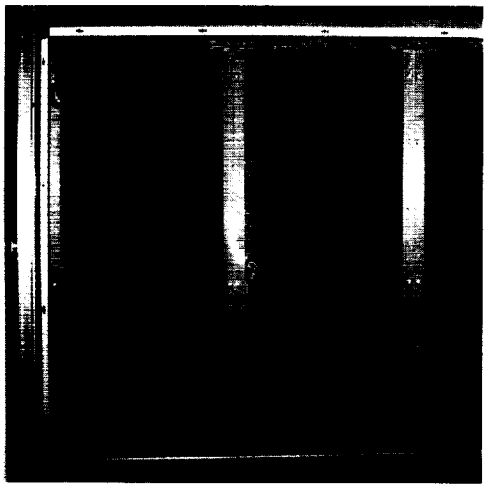

Figure 107
Photo No.: KSC-390C-2145.10
Dup. Neg. No.: L91-7659
LISAR No.: EL-1994-00503
Photo Credit: KSC
Photo Date: 3/21/90
Location: KSC SAEF II
Subject: Postflight Detail of Tray A7

***Figure 108 (Postflight).*** This close-up is of panels F-178/T300 cocured and PMR-15. The yellow identification numbers appear lighter. The fine horizontal lines, cracks, and crazing are still visible on the surface of each panel. The F-178/T300 cocured panel seems to have changed from the light gray in the in-flight photograph to a brownish gray. The geometric pattern visible on the PMR-15 panel in flight is not visible in this photograph. A gray haze or dust appears to cover the gray brown panel surface. Scratch marks and abrasions on the lower left edge of the panel were on preflight photographs.

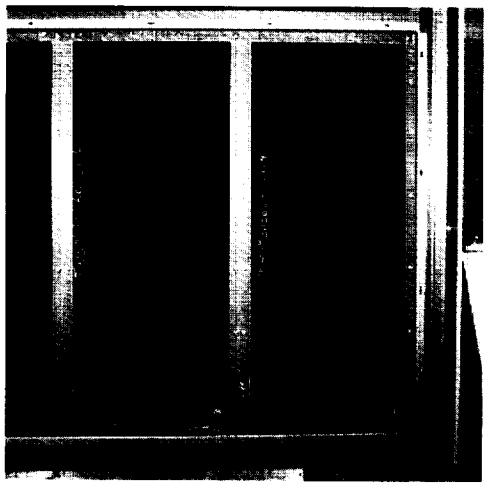

Figure 108
Photo No. KSC-390C-2145.11
Dup. Neg. No.: L91-7660
LISAR No.: EL-1994-00504
Photo Credit: KSC
Photo Date: 3/21/90
Location: KSC SAEF II
Subject: Postflight Detail of Tray A7

***Figure 109 (Postflight).*** This close-up photograph of the PMR-15 panel shows the geometric interference pattern that is visible when viewed from an oblique angle.

Figure 109
Photo No.: KSC-390C-2145.12
Dup. Neg. No.: L91-7661
LISAR No.: EL-1994-00505
Photo Credit: KSC
Photo Date: 3/21/90
Location: KSC SAEF II
Subject: Postflight Detail of Tray A7

## Tray A8

Solar Array Materials Passive LDEF Experiment (AO171)

NASA MSFC

NASA LeRC

NASA GSFC

Jet Propulsion Laboratory

Tray: A8

The objective of this experiment was to evaluate the synergistic effects of the space environment on solar array materials, such as solar cells, cover slips with various antireflectance (AR) coatings, adhesives, encapsulants, reflector materials, substrate strength materials, mast and harness materials, structural composites, and thermal control treatments.

***Figure 110 (Preflight).*** Six plates of passive components, provided by various organizations and designated plates I through VI, were mounted in the tray. Plate I, located in the upper right corner, consisted of a combination of solar cells with and without covers, solar cell modules, and solar arrays assembled on the baseplate. Plate II, located in the upper center section, had 27 composite samples (carbon fiber and glass fiber) mounted on the baseplate. Plate III, in the upper left corner, consisted mostly of metallized and thin polymeric specimens (such as Kapton, Mylar, Teflon, and white Tedlar films). Plate IV, located in the lower right corner, consisted of metals and coatings mounted in an aluminum baseplate and covered with a thin aluminum coverplate that partially masked the specimen. Plate V, in the lower center, contained thermal plastics and structural film configured into tensile and shear specimen. Plate VI, in the lower left, was populated with solar cells and associated components (covers, encapsulants, and adhesives).

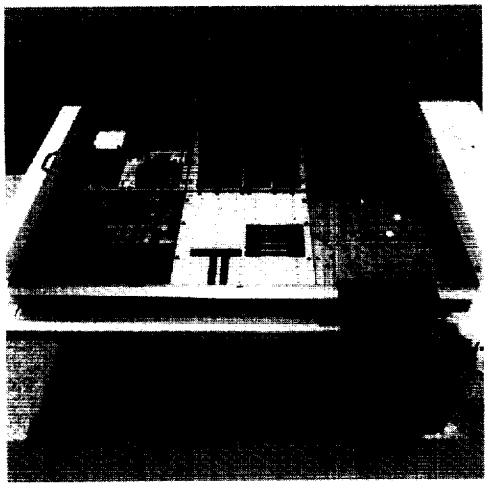

Figure 110
Photo No.: KSC-384C-538.10
Dup. Neg. No.: L89-4422
LISAR No.: EL-1994-00044
Photo Credit: KSC
Photo Date: 1/30/84
Location: KSC SAEF II
Subject: Preflight Survey of Tray A8

***Figure 111 (In Flight).*** Plate I, in the upper left, is shown with two of the four solar arrays missing and one solar cell appears to be attached at only one corner. Other components seem to be secure. The composites on Plate II in the left center appear to have no physical damage. On Plate III, in the lower left corner of the tray, the thin films without protective coatings on the lower left corner of the plate sustained significant damage or were destroyed. The metallized film apparently survived with minimum damage. On Plate IV, in the upper right corner, several of the coatings appear to have changed to a darker color and a light brown discoloration shows around the outer edges of the mounting plate and along the right edge of the coverplates. On Plate V, in the right center, all specimens, including the tape holding down the small specimen in the lower right corner, have darkened significantly during the extended time in space. On Plate VI, in the lower right corner, the solar cell components appear to have no physical damage. The colors of the test specimens, however, seem to have darkened.

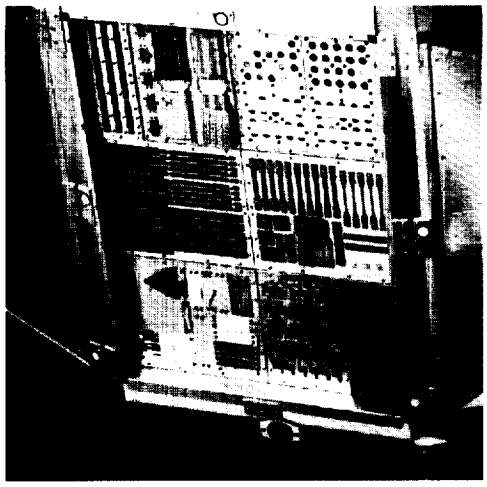

Figure 111
Photo No.: S32-76-027
Dup. Neg. No.: L90-10381
LISAR No.: EL-1994-00666
Photo Credit: JSC
Photo Date: 1/12/90
Location: In Flight
Subject: In-Flight Survey of Tray A8

***Figure 112 (Postflight).*** Most test specimens in the experiment appear to have survived intact, while the remaining specimens suffered varying degrees of deterioration. On Plate I in the upper right, three of the four solar arrays are missing. One solar array apparently was the one that was flying free near the LDEF just prior to retrieval and another was found in the Space Shuttle bay after the LDEF removal. On Plate III, in the upper left, thin films without protective coatings sustained significant damage or were destroyed.

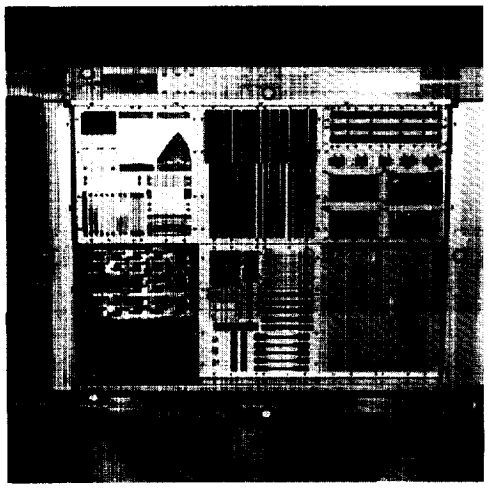

Figure 112
Photo No.: KSC-390C-1031.12
Dup. Neg. No.: L90-13422
LISAR No.: EL-1994-00147
Photo Credit: KSC
Photo Date: 2/9/90
Location: KSC SAEF II
Subject: Postflight Survey of Tray A8

***Figure 113 (Postflight).*** This close-up photograph of Plate III in the upper left one-sixth of the tray shows that the thin films without protective coatings sustained significant damage or were destroyed. The thin-film specimen, which is hanging by one end in the in-flight photograph, is missing. The metallized film apparently survived the mission with minimum damage.

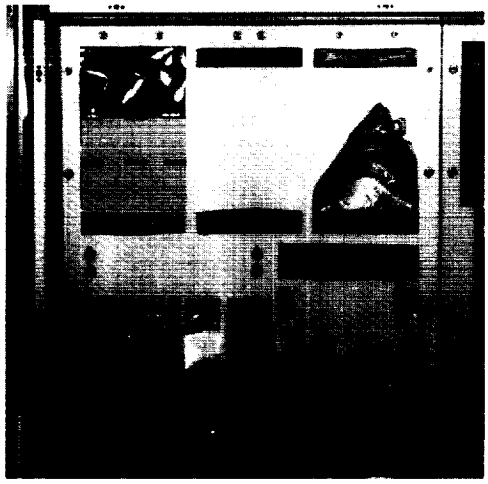

Figure 113
Photo No.: KSC-390C-1411.05
Dup. Neg.: L 91-7686
LISAR No.: EL-1994-00335
Photo Credit: KSC
Photo Date: 3/1/90
Location: KSC SAEF II
Subject: Postflight Detail of Upper Left of Tray A8

***Figure 114 (Postflight).*** In this close-up photograph of Plate II in the upper center one-sixth of the tray, the composites appear to have no physical damage.

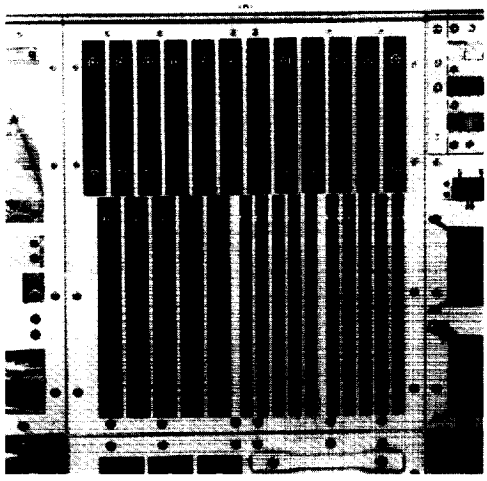

Figure 114
Photo No.: KSC-390C-1411.06
Dup. Neg. No.: L91-7687
LISAR No.: EL-1994-00336
Photo Credit: KSC
Photo Date: 3/1/90
Location: KSC SAEF II
Subject: Postflight Detail Survey of Upper Center of Tray A8

***Figure 115 (Postflight).*** On Plate I, in the upper right corner, three of the four solar arrays are missing. One apparently was the one flying free near the LDEF just prior to retrieval. (See fig. 21.) Another was found in the Space Shuttle bay after the LDEF removal. Other components appear to be secure.

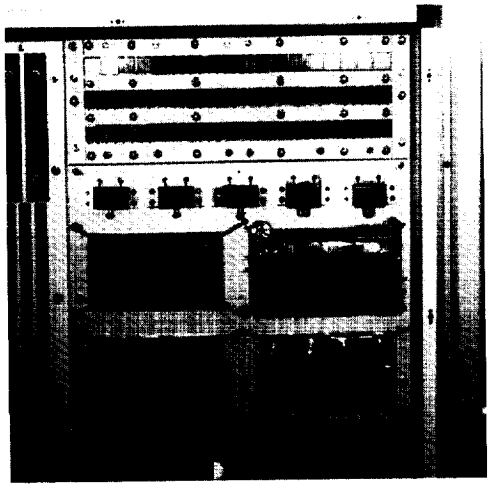

Figure 115
Photo No.: KSC-390C-1411.07
Dup. Neg. No.: L91-7688
LISAR No.: EL-1994-00337
Photo Credit: KSC
Photo Date: 3/1/90
Location: KSC SAEF II
Subject: Postflight Detail Survey of Upper Right of Tray A8

***Figure 116 (Postflight).*** This close-up photograph of Plate VI in the lower left one-sixth of the tray shows that the solar cell components appear to be without physical damage. The colors of the specimens seem to have darkened.

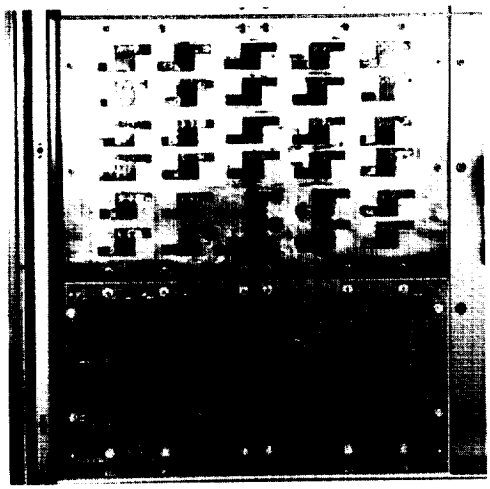

Figure 116
Photo No.: KSC-390C-1411.08
Dup. Neg. No.: L91-7689
LISAR No.: EL-1994-00338
Photo Credit: KSC
Photo Date: 3/1/9
Location: KSC SAEF II
Subject: Postflight Detail of Lower Left of Tray A8

***Figure 117 (Postflight).*** This close-up of Plate V in the lower center one-sixth of the tray shows that all specimens, including the tape holding down the small specimens in the lower left corner, have darkened significantly.

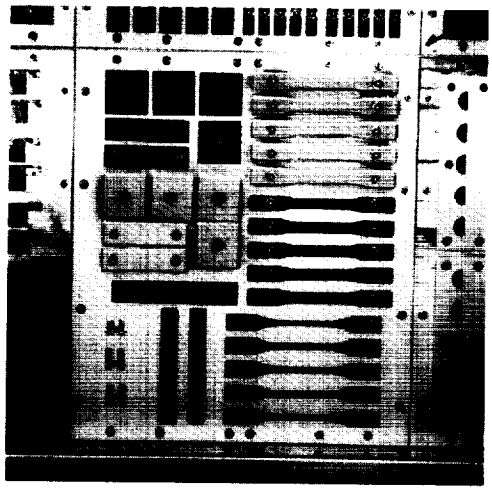

Figure 117
Photo No.: KSC-390C-1411.09
Dup. Neg. No.: L91-7690
LISAR No.: EL-1994-00361
Photo Credit: KSC
Photo Date: 3/1/90
Location: KSC SAEF II
Subject: Postflight Detail of Lower Center of Tray A8

***Figure 118 (Postflight).*** In this close-up of the lower right one-sixth of the tray, several of the coatings appear to have darkened and a unique pattern of light brown discoloration appears around the outer edges of the mounting plate and along the lower edge of the coverplates.

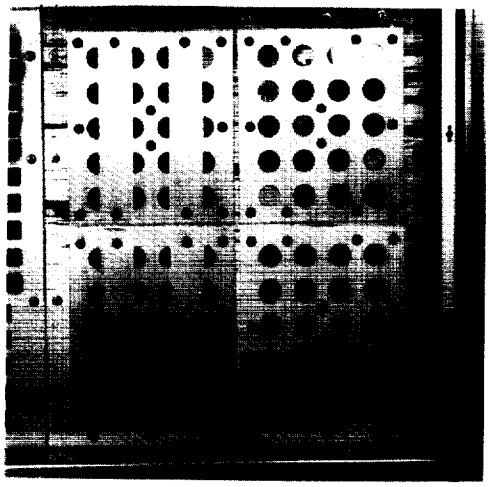

Figure 118
Photo No.: KSC-390C-1411.10
Dup. Neg. No.: L91-7691
LISAR No.: EL-1994-00362
Photo Credit: KSC
Photo Date: 3/1/90
Location: KSC SAEF II
Subject: Postflight Detail of Lower Right of Tray A8

## Tray A9

Thermal Control Surfaces Experiment (TCSE) (S0069)

NASA MSFC

Tray: A9

The objectives of this experiment were to determine the effects of the near-Earth orbital environment and the environment induced by the LDEF on spacecraft thermal control surfaces and to provide performance data on these surfaces.

***Figure 119 (Preflight).*** Experiment S0069 was self-contained; it included power, a data system, a reflectometer, and a preprogrammed controller for automatically exposing, monitoring, and measuring the sample materials. Experiment S0069 had 25 active and 24 passive samples mounted in a semicircular pattern (active samples on the outer radius and passive samples on the inner radius) on a circular carousel. This arrangement maximized the exposure of the samples to the combined space environment. Three radiometers were located on the innermost radius. The photograph shows the carousel rotated to the open position. The thermal shroud has an outside exposed surface covered with 2-mil silvered Teflon film bonded with an adhesive.

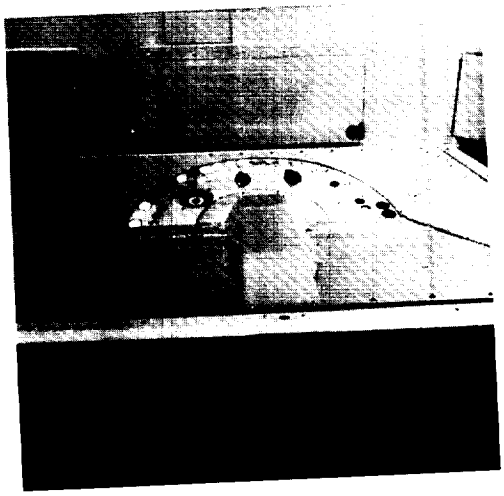

Figure 119
Photo No.: KSC-384C-209.03
Dup. Neg. No.: L84-7073
LISAR No.: EL-1994-00358
Photo Credit: KSC
Photo Date: 1/16/84
Location: KSC SAEF II
Subject: Preflight Survey of Tray A9

***Figure 120 (In Flight).*** Here, the original silver mirrorlike shroud surface appears white with copious amounts of a brown discoloration in a distinct pattern. The upper and lower triangular sections of the shroud have many irregular black discolorations and areas where the adhesive appears to have failed. Changes in color have occurred in both the active and the passive test samples. The three radiometers appear to have no physical damage.

Figure 120
Photo No.: S32-76-005
Dup. Neg. No.: L90-10375
LISAR No.: EL-1994-00660
Photo Credit: JSC
Photo Date: 1/12/90
Location: In Flight
Subject: In-Flight Survey of Tray A9

***Figure 121 (Postflight).*** The 2-mil silvered Teflon film surface on the shroud appears to be the same as in flight. It is white with brown discolorations in a distinct pattern. The left and right triangular sections of the shroud have many irregular black discolorations and areas where the adhesive appears to have failed.

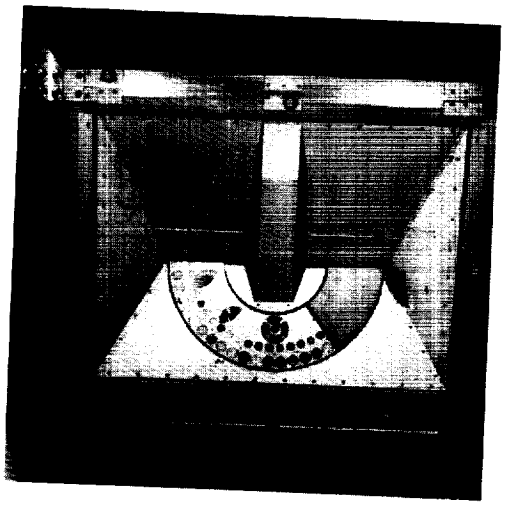

Figure 121
Photo No.: KSC-390C-1030.11
Dup. Neg. No.: L90-13409
LISAR No.: EL-1994-00144
Photo Credit: KSC
Photo Date: 2/9/90
Location: KSC SAEF II
Subject: Postflight Survey of Tray A9

***Figure 122 (Postflight).*** This close-up photograph is of the carousel and test specimens. Note the discoloration streaks on the silvered Teflon film in the upper portions of the photograph and the evidence of numerous small impact discolorations. While changes in color have occurred in both the active and passive test samples, they appear to be the same as in flight. The three radiometers seem to be without physical damage.

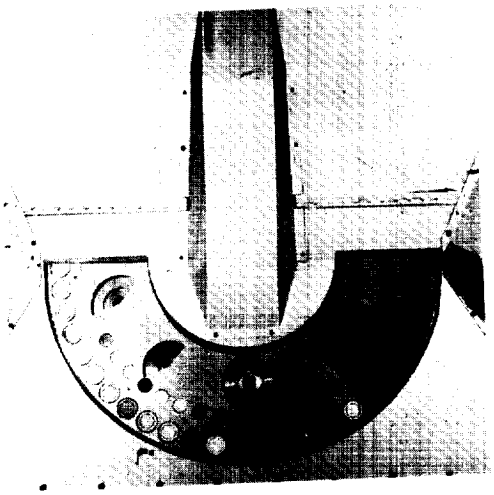

Figure 122
Photo No.: KSC-390C-1419.03
Dup. Neg. No.: L91-7715
LISAR No.: EL-1994-00375
Photo Credit: KSC
Photo Date: 2/28/90
Location: KSC SAEF II
Subject: Postflight Detail of Tray A9

***Figure 123 (Postflight).*** This close-up photograph is of the left area of the exposed test samples. The calorimeter outer edge appears to be deformed in the fourth from top (outer) active sample location. The passive samples, located on the inner radius, seem to have no physical damage; however, some of the white paint samples now appear brown or tan. A point of space debris impact is located just off the edge of the carousel.

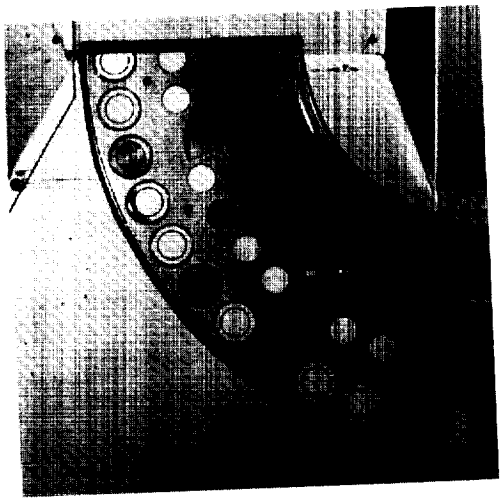

Figure 123
Photo No.: KSC-390C-1419.04
Dup. Neg. No.: L91-7716
LISAR No.: EL-1994-00376
Photo Credit: KSC
Photo Date: 2/28/90
Location: KSC SAEF II
Subject: Postflight Detail of Tray A9

***Figure 124 (Postflight).*** This close-up is of the center area of the exposed test specimens. Some of the test specimens appear discolored and damaged. Note the first four from the right active coating samples, which are located on the outer radius. Two of the first three, which were originally white, now appear brown and have significant damage. The fourth active sample from the right, which was originally black, appears to have eroded, thus leaving only a trace of the paint or primer on the substrate. The passive samples, located on the inner radius, appear to have no physical damage; however, some of the white paint samples now appear brown or tan.

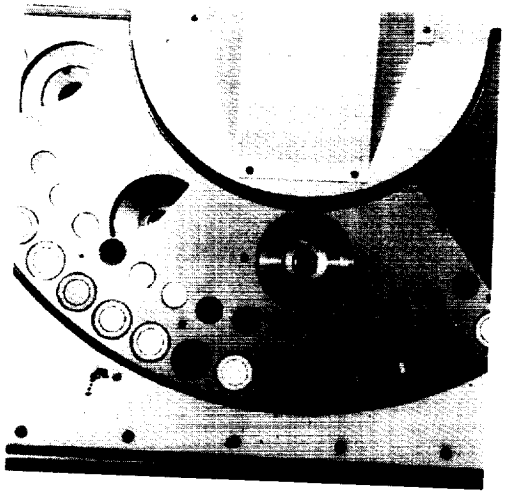

Figure 124
Photo No.: KSC-390C-1419.05
Dup. Neg. No.: L91-7717
LISAR No.: EL-1994-00377
Photo Credit: KSC
Photo Date: 2/28/90
Location: KSC SAEF II
Subject: Postflight Detail of Tray A9

***Figure 125 (Postflight).*** This close-up photograph is of the right area of the exposed test specimens. Some of the test specimens are discolored and damaged. Note the first four from the right active coating samples located on the outer radius. Two of the first three, which were originally white, now appear brown and have significant damage. The fourth active sample from the right, which was originally black, appears to have eroded, thus leaving only a trace of the paint or primer on the substrate. The passive samples, located on the inner radius, appear to have no physical damage; however, some of the white paint samples now appear brown or tan.

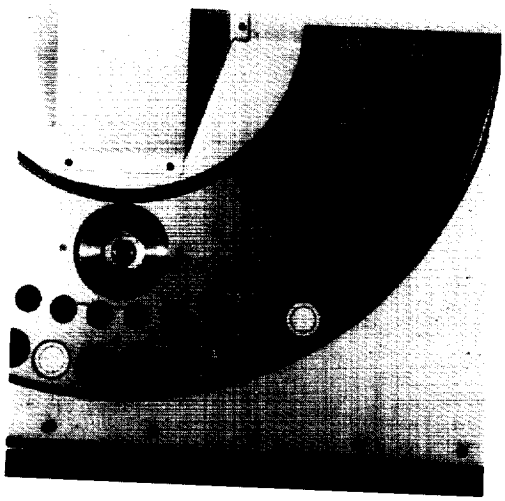

Figure 125
Photo No.: KSC-390C-1419.06
Dup. Neg. No.: L91-7718
LISAR No.: EL-1994-00378
Photo Credit: KSC
Photo Date: 2/28/90
Location: KSC SAEF II
Subject: Postflight Detail of Tray A9

***Figure 126 (Postflight).*** This close-up of the right area of the carousel and tray bottom shows the area of damaged silvered Teflon film. Numerous discolorations from space debris impacts are also visible.

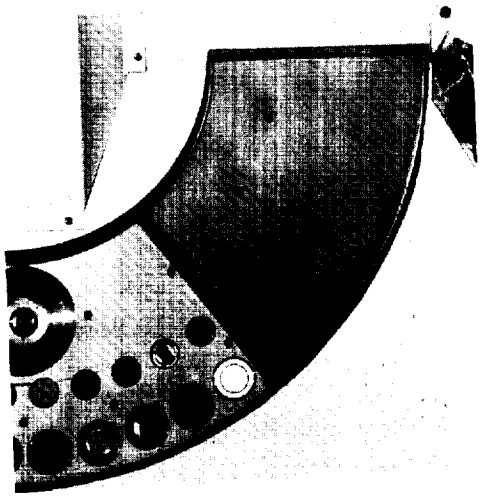

Figure 126
Photo No.: KSC-390C-1419.07
Dup. Neg. No.: L91-7719
LISAR No.: EL-1994-00379
Photo Credit: KSC
Photo Date: 2/28/90
Location: KSC SAEF II
Subject: Postflight Detail of Tray A9

## Tray A10

A High-Resolution Study of Ultraheavy Cosmic Ray Nuclei (UHCRE) (AO178)

Dublin Institute for Advanced Studies

ESA at ESTEC

Trays: A2, A4, A10, B5, B7, C5, C6, C8, C11, D1, D5, D7, D11, E2, E10, and F4

See section entitled "Tray D5" and figure 319 for a typical preflight photograph of experiment AO178.

***Figure 127 (In Flight).*** Note the dark brown stain on the LDEF structure adjacent to the edge of the black thermal panel. The thermal cover surface of experiment AO178 appears to have changed from specular to opaque with many black dots of various sizes that appear to be impact or penetration discolorations. A large discoloration is clearly visible in the lower right quadrant of the thermal cover. Many discolorations appear to be encircled by white halos. Numerous circular white discolorations that seem to be impacts are visible on the surface of the cover. The cover appears to be more taut than in the prelaunch photograph and the locations of Velcro attachment pads are apparent. The ground strap appears to be in place and to have no visible damage, but it appears to be a darker color.

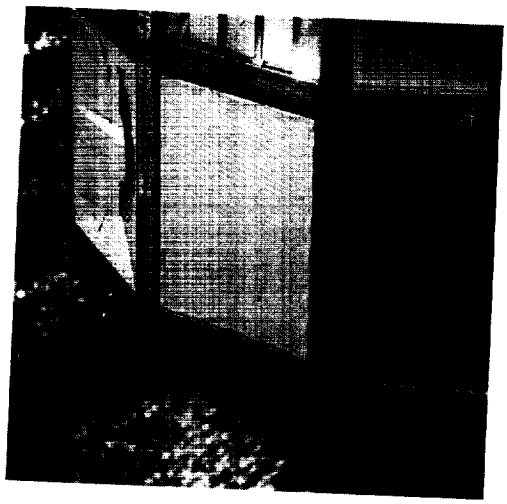

Figure 127
Photo No.: S32-78-079
Dup. Neg. No.: L90-10445
LISAR No.: EL-1994-00018
Photo Credit: JSC
Photo Date: 1/12/90
Location: In Flight
Subject: In-Flight Survey of Tray A10

***Figure 128 (Postflight).*** The thermal cover surface appears to have changed from specular to opaque (glossy white) with many black dots of various sizes. These black dots are probably the results of impacts or penetrations of the 5-mil Teflon film that allowed atomic oxygen to oxidize and erode the layer of vapor-deposited silver beneath. The cover is not as taut as in the in-flight photograph and locations of Velcro attachment pads are not as prominent. The ground strap appears to be in place and to have no visible damage, but it appears to be a deeper copper color. The cradled RMS arm is visible at the upper edge of the photograph.

Figure 128
Photo No.: KSC-390C-612.01
Dup. Neg.: L92-17792
LISAR No.: EL-1994-00122
Photo Credit: KSC
Photo Date: 1/30/90
Location: KSC OPF
Subject: Postflight Survey of Tray A10

***Figure 129 (Postflight).*** This close-up photograph of the upper left one-sixth of the tray shows numerous space debris impact or penetration discolorations. White dots of various sizes are visible on the cover and many appear to be encircling impact locations. The silvered Teflon film surface appears diffuse rather than specular as it was in preflight photographs.

Figure 129
Photo No.: KSC-390C-2208.03
Dup Neg. No.: L91-7776
LISAR No.: EL-1994-00509
Photo Credit: KSC
Photo Date: 3/22/90
Location: KSC SAEF II
Subject: Postflight Detail of Upper Left of Tray A10

***Figure 130 (Postflight).*** This photograph is of the upper center one-sixth of the tray. It shows numerous space debris impact or penetration discolorations. White dots of various sizes are visible on the cover and many appear to be encircling impact locations. The silvered Teflon film surface appears diffuse rather than specular as it was in preflight photographs.

Figure 130
Photo No.: KSC-390C-2208.04
Dup. Neg.: L91-7777
LISAR No.: EL-1994-00510
Photo Credit: KSC
Photo Date: 3/22/90
Location: KSC SAEF II
Subject: Postflight Detail of Upper Center of Tray A10

***Figure 131 (Postflight).*** This photograph is of the upper right one-sixth of the tray. It shows numerous space debris impact or penetration discolorations. White dots of various sizes are visible on the cover and many seem to be encircling impact locations. The silvered Teflon film surface appears diffuse rather than specular as it was in preflight photographs.

Figure 131
Photo No.: KSC-390C-2208.05
Dup. Neg. No.: L91-7778
LISAR No.: EL-1994-00530
Photo Credit: KSC
Photo Date: 3/22/90
Location: KSC SAEF II
Subject: Postflight Detail of Upper Right of Tray A10

***Figure 132 (Postflight).*** This photograph is of the lower left one-sixth of the tray. It shows numerous space debris impact or penetration discolorations. White dots of various sizes are visible on the cover and many appear to be encircling impact locations. The silvered Teflon film surface appears diffuse rather than specular as it was in preflight photographs. One large discoloration spot is in the upper center of the photograph.

Figure 132
Photo No.: KSC-390C-2208.09
Dup. Neg. No.: L91-7782
LISAR No.: EL-1994-00531
Photo Credit: KSC
Photo Date: 3/22/90
Location: KSC SAEF II
Subject: Postflight Detail of Lower Left of Tray A10

***Figure 133 (Postflight).*** This photograph is of the lower center one-sixth of the tray. It shows numerous space debris impact or penetration discolorations. White dots of various sizes are visible on the cover and many appear to be encircling impact locations. The silvered Teflon film surface appears diffuse rather than specular as it was in preflight photographs.

Figure 133
Photo No.: KSC-390C-2208.10
Dup. Neg. No.: L91-7783
LISAR No.: EL-1994-00532
Photo Credit: KSC
Photo Date: 3/22/90
Location: KSC SAEF II
Subject: Postflight Detail of Lower Center of Tray A10

***Figure 134 (Postflight).*** This photograph is of the lower right one-sixth of the tray. It shows numerous space debris impact or penetration discolorations. White dots of various sizes are visible on the cover and many appear to be encircling impact locations. The silvered Teflon film surface appears diffuse rather than specular as it was in preflight photographs.

Figure 134
Photo No.: KSC-390C-2208.11
Dup. Neg. No.: L91-7784
LISAR No.: EL-1994-00533
Photo Credit: KSC
Photo Date: 3/22/90
Location: KSC SAEF II
Subject: Postflight Detail of Lower Right of Tray A10

***Figure 135 (Postflight).*** This close-up photograph is of the large discolored impact or penetration located in the lower left one-sixth of the tray. A large lighter area of discoloration surrounds the darker area. The upper left side of the photograph is light because of photographic lights.

Figure 135
Photo No.: KSC-390C-2208.12
Dup. Neg. No.: L91-7785
LISAR No.: EL-1994-00534
Photo Credit: KSC
Photo Date: 3/22/90
Location: KSC SAEF II
Subject: Postflight Detail of Impact or Penetration in Tray A10

## Tray A11

The Chemistry of Micrometeoroids (AO187-1)

NASA JSC

University of Washington

Rockwell International Science Center

Trays: A3 and A11

The objective of this experiment was to retrieve analyzable projectile residue associated with hypervelocity craters.

***Figure 136 (Preflight).*** This passive unit of experiment AO187-1 exposes six aluminum (99.9-percent pure) panels (47 cm by 41 cm by 0.3 cm each) to the space environment. The active unit of this experiment is in tray A3. The plates were unprotected and were exposed to the total mission environment (i.e., ground handling as well as flight).

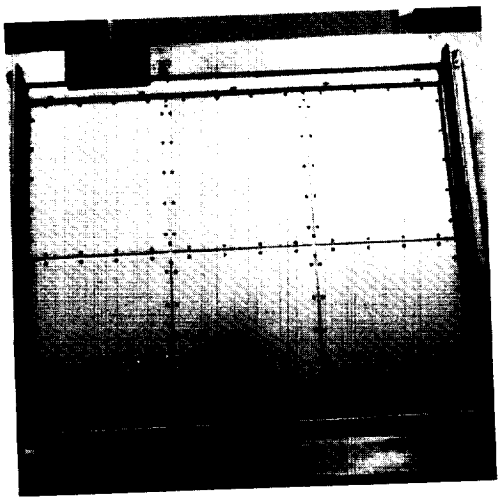

Figure 136
Photo No.: KSC-384C-538.01
Dup. Neg. No.: L89-4413
LISAR No.: EL-1994-00031
Photo Credit: KSC
Photo Date: 1/30/84
Location: KSC SAEF II
Subject: Preflight Survey of Tray A11

***Figure 137 (In Flight).*** The experiment appears to be intact. Impact craters, which appear as small white imperfections in the dark blue background, are visible on all six detector plates. The apparent dark blue of the aluminum detector panels in this photograph is the result of the lighting and the camera angle.

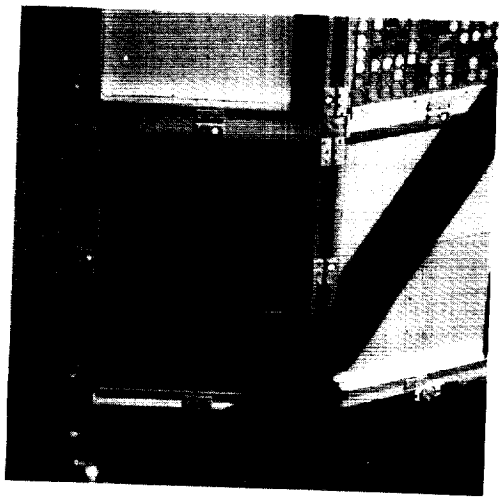

Figure 137
Photo No.: S32-78-058
Dup. Neg. No.: L90-10438
LISAR No.: EL-1994-00013
Photo Credit: JSC
Photo Date: 1/12/90
Location: In Flight
Subject: In-Flight Survey of Tray A11

***Figure 138 (Postflight).*** Close inspection of the postflight photograph reveals tiny white spots on the detector plates where impacts have occurred during flight. The largest impact appears to have been on the plate in the lower left corner of the experiment tray.

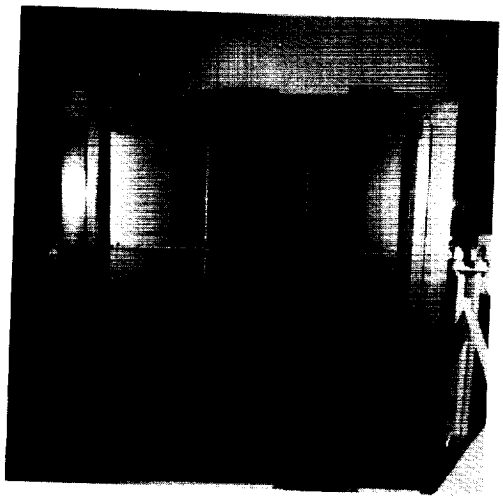

Figure 138
Photo No.: KSC-390C-1697.10
Dup. Neg. No.: L91-7805
LISAR No.: EL-1994-00263
Photo Credit: KSC
Photo Date: 3/7/90
Location: KSC SAEF II
Subject: Postflight Survey of Tray A11

***Figure 139 (Postflight).*** This close-up photograph is of the upper left plate. The very small white dots are impact craters. The lighter area to the left is a result of photographic light reflections.

Figure 139
Photo No.: KSC-390C-1697.11
Dup. Neg. No.: L91-7806
LISAR No.: EL-1994-00228
Photo Credit: KSC
Photo Date: 3/7/90
Location: KSC SAEF II
Subject: Postflight Detail of Upper Left Plate of Tray A11

***Figure 140 (Postflight).*** This close-up photograph is of the upper center plate. The very small white dots are impact craters.

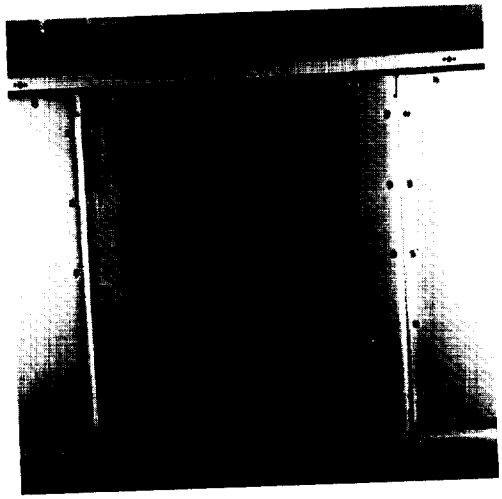

Figure 140
Photo No.: KSC-390C-1697.12
Dup. Neg. No.: L91-7807
LISAR No.: EL-1994-00229
Photo Credit: KSC
Photo Date: 3/7/90
Location: KSC SAEF II
Subject: Postflight Detail of Upper Center Plate of Tray A11

***Figure 141 (Postflight).*** This close-up photograph is of the upper right plate. The very small white dots are impact craters.

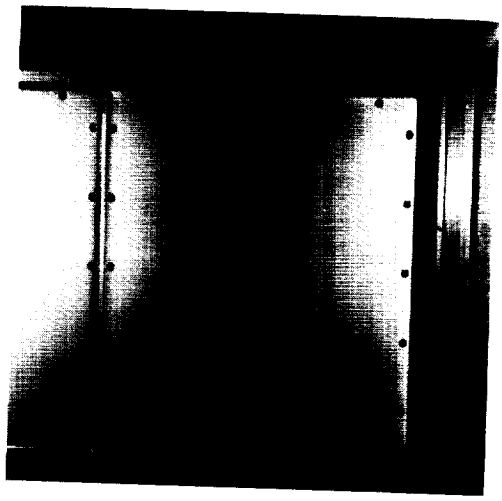

Figure 141
Photo No.: KSC-390C-1699.02
Dup. Neg. No.: L91-7815
LISAR No.: EL-1994-00230
Photo Credit: KSC
Photo Date: 3/7/90
Location: KSC SAEF II
Subject: Postflight Detail of Upper Right Plate of Tray A11

***Figure 142 (Postflight).*** This close-up photograph is of the lower left plate. The very small white dots are impact craters. The upper left has what appears to be a bulge in the panel. This bulge can be found in preflight photographs and is not a result of flight.

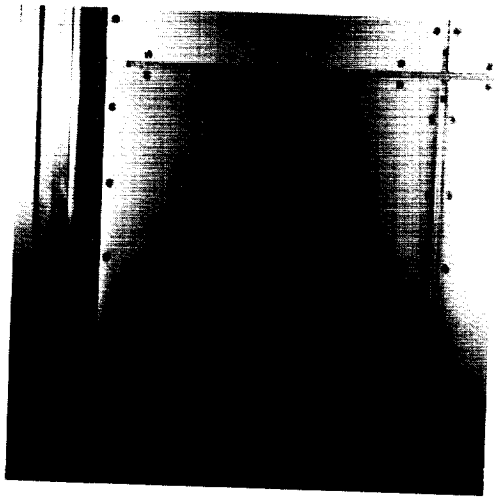

Figure 142
Photo No.: KSC-390C-1699.03
Dup. Neg. No.: L91-7816
LISAR No.: EL-1994-00231
Photo Credit: KSC
Photo Date: 3/7/90
Location: KSC SAEF II
Subject: Postflight Detail of Lower Left Plate of Tray A11

***Figure 143 (Postflight).*** This close-up photograph is of the lower center plate. The very small white dots are impact craters.

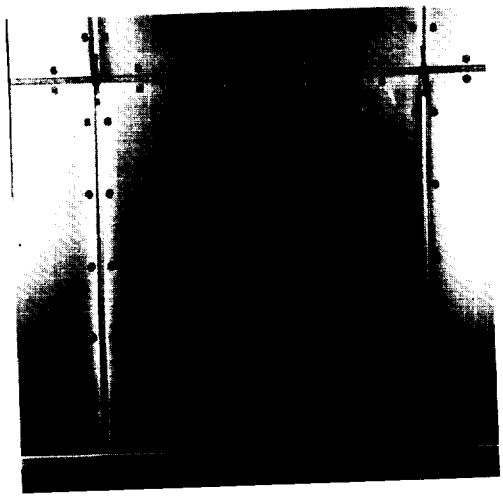

Figure 143
Photo No.: KSC-390C-1699.04
Dup. Neg. No.: L91-7817
LISAR No.: EL-1994-00232
Photo Credit: KSC
Photo Date: 3/7/90
Location: KSC SAEF II
Subject: Postflight Detail of Lower Center Plate of Tray A11

***Figure 144 (Postflight).*** This close-up photograph is of the lower right plate. The very small white dots are impact craters. The left part of the photograph shows photographic light reflections.

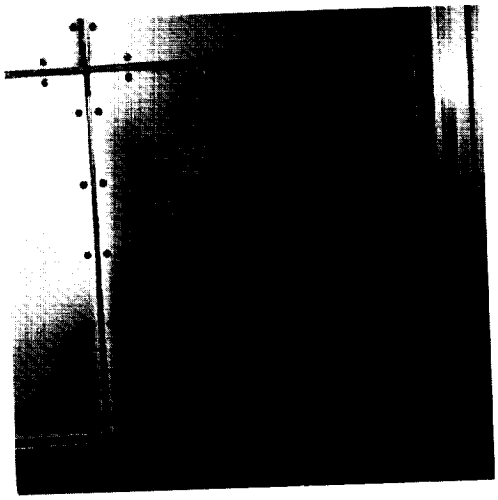

Figure 144
Photo No.: KSC-390C-1699.05
Dup. Neg. No.: L91-7818
LISAR No.: EL-1994-00233
Photo Credit: KSC
Photo Date: 3/7/90
Location: KSC SAEF II
Subject: Postflight Detail of Lower Right Plate of Tray A11

## Tray A12

Space Debris Impact Experiment (S0001)

NASA LaRC

Trays: A5, A6, A12, B1, B2, B6, B8, B11, C4, C7, D2, D6, E1, E4, E7, E11, F1, F3, F5, F7, F10, F11, G4, G8, and H5

See section entitled "Tray A5" for a typical preflight photographic survey and experiment objective.

***Figure 145 (In Flight).*** The greenish-gray tint on the two debris panels is the by-product of the chromic anodization coating process. The blue tint can be attributed to reflections of the sky. The vertical streaks on the debris panels are by-products of chromic anodizing; these streaks have been enhanced by the blue reflection. Brown stains are located along the left edge of the right debris panel. An irregular discoloration extends horizontally across the lower half of the left debris panel. The light band along the vertical edge of the left debris panel and across the top of both debris panels is a reflection from the tray sidewall.

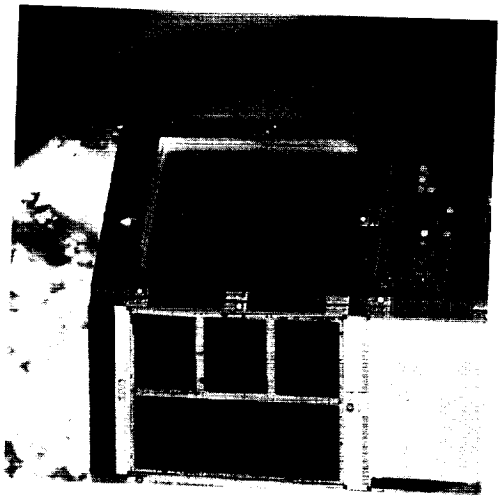

Figure 145
Photo No.: S32-78-029
Dup. Neg. No.: L90-10430
LISAR No.: EL-1994-00006
Photo Credit: JSC
Photo Date: 1/12/90
Location: In Flight
Subject: In-Flight Survey of Tray A12

***Figure 146 (Postflight).*** The pink and greenish-gray tints on the two debris panels are by-products of the chromic anodization coating process and are not attributed to contamination or exposure to the space environment. The vertical streaks observed on the right debris panel in the in-flight photograph are still visible, although they are not as distinct. The irregular discoloration extending horizontally across the left debris panel remains well defined. The light band across the top and bottom of the debris panels is caused by light reflecting from the tray sidewalls.

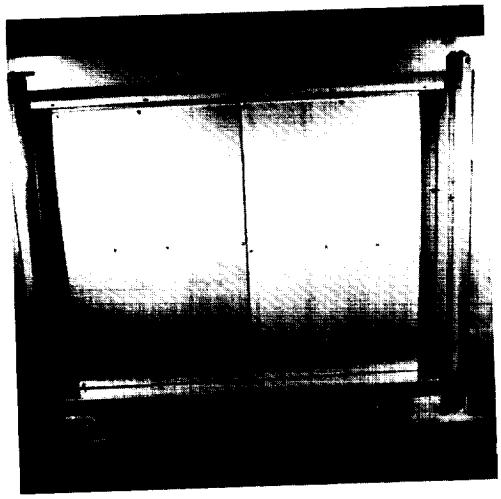

Figure 146
Photo No.: KSC-390C-2163.03
Dup. Neg.: L91-7828
LISAR No.: EL-1994-00472
Photo Credit: KSC
Photo Date: 3/21/90
Location: KSC SAEF II
Subject: Postflight Survey of Tray A12

## Tray B1

Space Debris Impact Experiment (S0001)

NASA LaRC

Trays: A5, A6, A12, B1, B2, B6, B8, B11, C4, C7, D2, D6, E1, E4, E7, E11, F1, F3, F5, F7, F10, F11, G4, G8, and H5

See Tray A5 for the preflight survey.

See section entitled "Tray A5" for a typical preflight photographic survey and experiment objective.

***Figure 147 (In Flight).*** The pink and greenish-gray tints on the two debris panels are by-products of the chromic anodization coating process and are not attributed to contamination or exposure to the space environment.

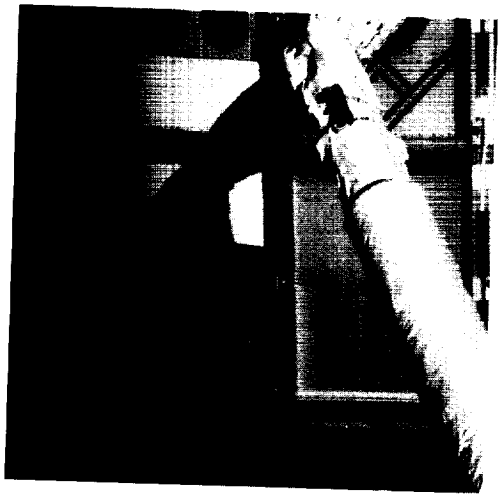

Figure 147
Photo No.: S32-78-026
Dup. Neg. No.: L90-10429
LISAR No.: EL-1994-00005
Photo Credit: JSC
Photo Date: 1/12/90
Location: In Flight
Subject: In-Flight Survey of Tray B1

***Figure 148 (Postflight).*** The pink and greenish-gray tints on the two debris panels are by-products of the chromic anodization coating process and are not attributed to contamination or exposure to the space environment. The light bands along the bottom and the left and right edges of the panels are caused by lights reflecting from the tray sidewalls. The two small mounds on the panel on the left are manufacturing defects that existed prior to flight. Markings along the top of the photograph are the result of film processing.

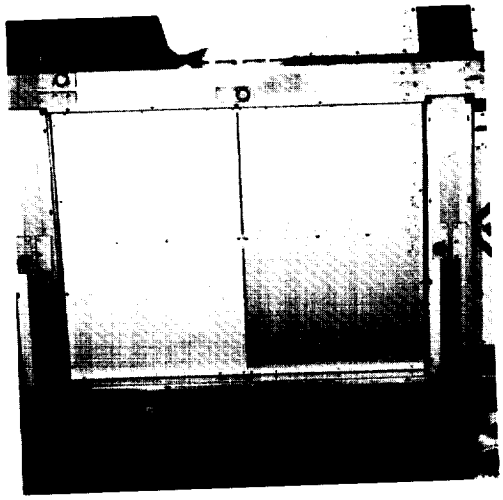

Figure 148
Photo No.: KSC-390C-1066.11
Dup. Neg. No.: L90-13480
LISAR No.: EL-1994-00189
Photo Credit: KSC
Photo Date: 2/8/90
Location: KSC SAEF II
Subject: Postflight Survey of Tray B1

## Tray B2

Space Debris Impact Experiment (S0001)

NASA LaRC

Trays: A5, A6, A12, B1, B2, B6, B8, B11, C4, C7, D2, D6, E1, E4, E7, E11, F1, F3, F5, F7, F10, F11, G4, G8, and H5

See section entitled "Tray A5" for a typical preflight photographic survey and experiment objective.

***Figure 149 (In Flight).*** The greenish-gray tint on the left debris panels and the pink tint on the right debris panel are by-products of the chromic anodization coating process. The light band along the left side and across the bottom of the panels is caused by light reflecting from the tray sidewalls.

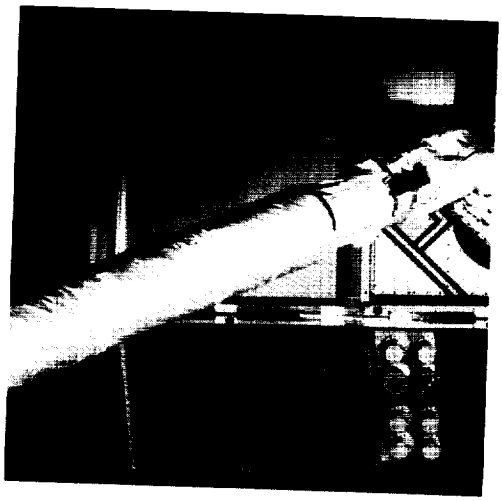

Figure 149
Photo No.: S32-78-016
Dup. Neg.: L90-10427
LISAR No.: EL-1994-00004
Photo Credit: JSC
Photo Date: 1/12/90
Location: In Flight
Subject: In-Flight Survey of Tray B2

***Figure 150 (Postflight).*** The pink and greenish-gray tints on the two debris panels are by-products of the chromic anodization coating process and are not attributed to contamination or exposure to the space environment. The light band along the sides and across the bottom of the panels is caused by light reflecting from the tray sidewalls.

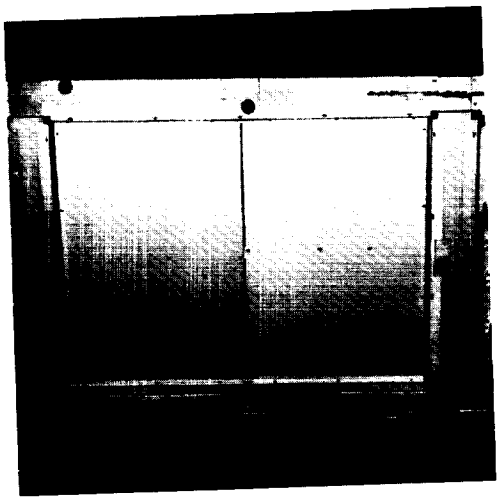

Figure 150
Photo No.: KSC-390C-1066.05
Dup. Neg. No.: L90-13474
LISAR No.: EL-1994-00386
Photo Credit: KSC
Photo Date: 2/8/90
Location: KSC SAEF II
Subject: Postflight Survey of Tray B2

## Tray B3

Study of Meteoroid Impact Craters on Various Materials (AO138-1)

CERT/ONERA-DERTS

Tray: B3

The objective of this experiment was to study impact craters produced by micrometeoroids (interplanetary dust particles) on selected materials (tungsten, aluminum, gold, copper, stainless steel, and Pyrex glass).

Attempt at Dust Debris Collection With Stacked Detectors (AO138-2)

CERT/ONERA-DERTS

Tray: B3

The objective of this experiment was to investigate the feasibility of future missions of multilayer thin film that is composed of multilayer thin-foil detectors, which acted as energy sorters to collect micrometeoroids for chemical analysis.

Thin Metal Film and Multilayers Experiment (AO138-3)

CNRS/LPSP

Tray: B3

This experiment investigated the effects of the space environment on vacuum UV optical components (EUV thin films, UV gas filters, photocathodes, and UV crystal filters) for use in the development and the qualification of new UV optical components.

Vacuum-Deposited Optical Coatings Experiment (AO138-4)

Optical Division, Matra S.A.

Tray: B3

This experiment investigated the long-term stability of a wide range of vacuum-deposited optical coatings used in spacecraft optical and electro-optical instruments.

Ruled and Holographic Gratings Experiment (AO138-5)

Jobin-Yvon Division, Instruments S.A.

Tray: B3

This experiment studied the effects of exposure to the space environment on ruled and holographic gratings used in spacecraft optical and electro-optical instruments.

Thermal Control Coatings Experiment (AO138-6)

CERT/ONERA-DERTS

CNES/CST

Tray: B3

This experiment examined the validity of ground simulations of space environment for studies on degradation of thermal control coatings used on satellites.

Optical Fibers and Components Experiment (AO138-7)

CERT/ONERA-DERTS

Tray: B3

The objective of this experiment was to examine the radiation effects on fiber-optic wave guides, which are important components in communication systems, optoelectronics circuits, and data links.

Effect of Space Exposure of Some Epoxy Matrix Composites on Their Thermal Expansion and Mechanical Properties (AO138-8)

Space Division, Matra S.A.

Tray: B3

This experiment examined the effects of space exposure on the coefficient of thermal expansion of composites and epoxy resins commonly used in space structures.

The Effect of the Space Environment on Composite Materials (AO138-9)

Aérospatiale

Tray: B3

The objective of this passive experiment was to assess the degradation of graphite-fiber-reinforced epoxy matrix composite materials, adhesives, and thermal coatings.

Microwelding of Various Metallic Materials Under Ultravacuum (AO138-10)

Aérospatiale

Tray: B3

The objective of this experiment was to study the molecular diffusion of adjacent metals in the ultrahigh vacuum of space.

***Figure 151 (Preflight).*** The FRECOPA was self-contained in a 12-in-deep tray, which consisted of three canisters and an aluminum mounting plate. The canisters, which opened after the LDEF was placed in orbit, were used to expose sample materials of nine different experiments to the space environment for 10 months; the mounting plate was exposed for the entire mission. The photograph shows the location of the three one-sixth experiment sections that were covered by aluminum plates with openings that accommodated the open canisters, the two one-sixth sections covered with Teflon and glass thermal covers, and the one-sixth section populated with test samples. Material samples are also attached to the top corners of the canister cover plates, which are located in the upper right and upper left corners of the experiment tray.

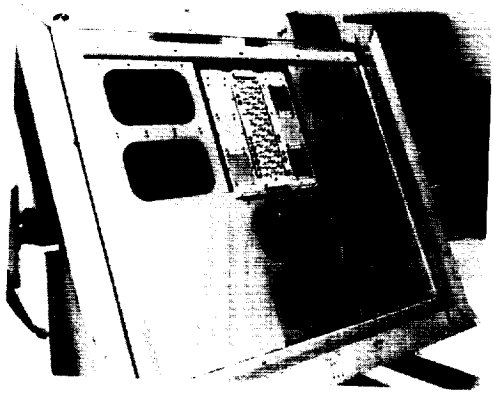

Figure 151
Photo No.: KSC-384C-330.01
Dup. Neg. No.: L84-7170
LISAR No.: EL-1994-00645
Photo Credit: KSC
Photo Date: 1/24/84
Location: KSC SAEF II
Subject: Preflight Survey of Tray B3

***Figure 152 (In Flight).*** The experiment appears to be without physical damage except for a tear in the material behind the Teflon and glass thermal cover in the lower left corner. Both the mounting plate of the experiment AO138-1 and the plates that provide masks for the open canisters seals have stained surfaces. The exposed experiment mounting plate, however, appears to have a much darker discoloration. The material samples on the top corners of the two upper plates that provide masks for the open canister seals do not appear to be discolored.

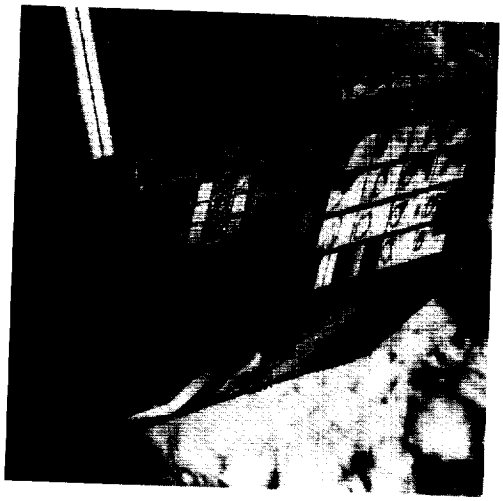

Figure 152
Photo No.: S32-77-058
Dup. Neg. No.: L90-10415
LISAR No.: EL-1994-00681
Photo Credit: JSC
Photo Date: 1/12/90
Location: In Flight
Subject: In-Flight Survey of Tray B3

***Figure 153 (Postflight).*** The experiment appears to have no physical damage except for a tear in thermal cover and some discolored areas. The material samples on the bottom corners of the two lower canister cover plates do not appear to be discolored.

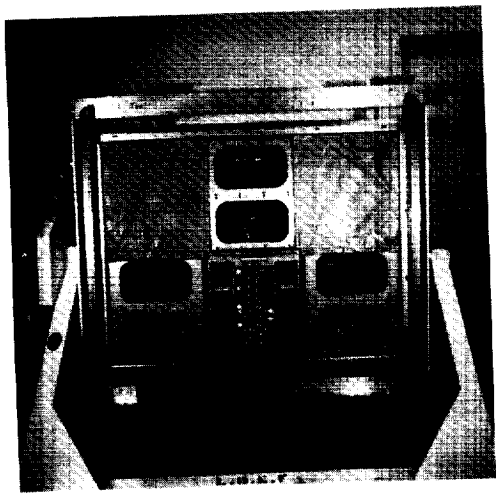

Figure 153
Photo No.: KSC-390C-1646.09
Dup. Neg. No.: L91-7874
LISAR No.: EL-1994-00217
Photo Credit: KSC
Photo Date: 3/6/90
Location: KSC SAEF II
Subject: Postflight Survey of Tray B3

***Figure 154 (Postflight).*** This close-up of the upper left of the lower center of the tray shows that the experiment mounting plate has a darker color than before flight. The test samples appear wrinkled but are intact.

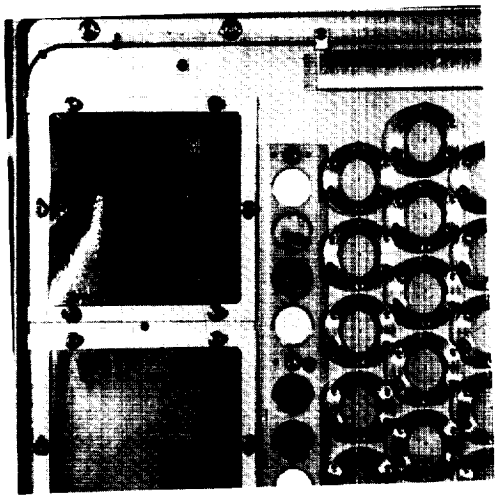

Figure 154
Photo No.: KSC-390C-1648.08
Dup. Neg. No.: L91-7895
LISAR No.: EL-1994-00368
Photo Credit: KSC
Photo Date: 3/6/90
Location: KSC SAEF II
Subject: Postflight Detail of Upper Left of Lower Center of Tray B3

***Figure 155 (Postflight).*** This close-up of the upper right of the lower center of the tray shows that the experiment mounting plate has a darker color than before flight.

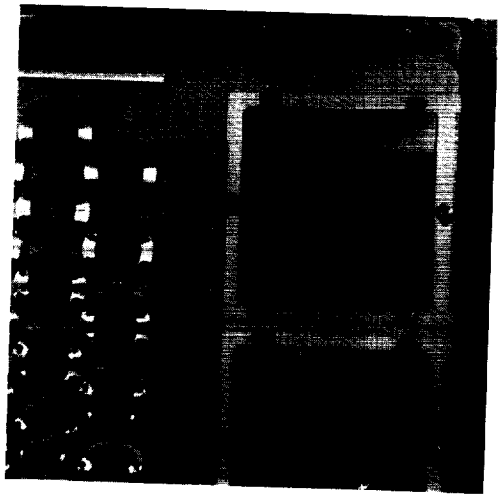

Figure 155
Photo No.: KSC-390C-1648.09
Dup. Neg. No.: L91-7896
LISAR No.: EL-1994-00197
Photo Credit: KSC
Photo Date: 3/6/90
Location: KSC SAEF II
Subject: Postflight Detail of Upper Right of Lower Center of Tray B3

***Figure 156 (Postflight).*** This close-up of the lower right of the lower center of the tray shows that the experiment mounting plate has a darker color than before flight. The test samples appear intact.

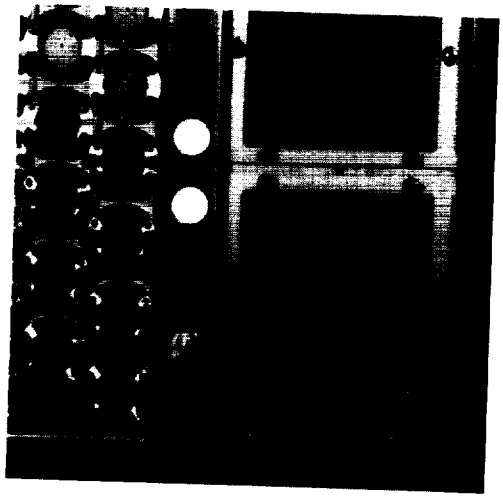

Figure 156
Photo No.: KSC-390C-1648.10
Dup. Neg. No.: L91-7897
LISAR No.: EL-1994-00198
Photo Credit: KSC
Photo Date: 3/6/90
Location: KSC SAEF II
Subject: Postflight Detail of Lower Right of Center of Tray B3

***Figure 157 (Postflight).*** This close-up of the lower left of the lower center tray shows that the experiment mounting plate is a darker color than before flight. The test samples appear wrinkled but are intact.

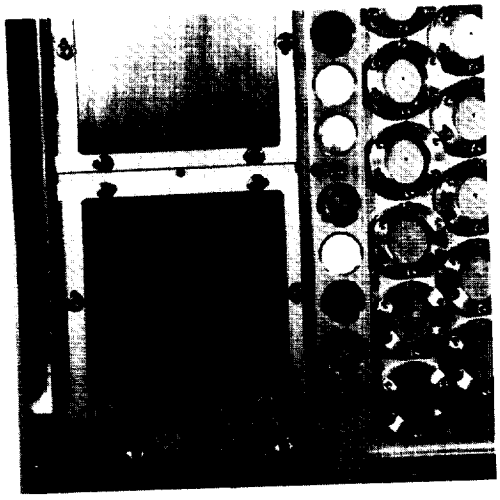

Figure 157
Photo No.: KSC-390C-1649.01
Dup. Neg. No.: L91-7899
LISAR No.: EL-1994-00218
Photo Credit: KSC
Photo Date: 3/6/90
Location: KSC SAEF II
Subject: Postflight Detail of Lower Left of Lower Center of Tray B3

## Tray B4

Space Plasma High-Voltage Drainage Experiment (SP HVD) (AO054)

TRW Space and Technology Group

Trays: B4 and D10

The objective of this experiment was to place large numbers of dielectric samples under electric stress in space to determine the long-term leakage of the dielectrics and the material degradation caused by both the low-Earth-orbit environment and the high-voltage systems.

***Figure 158 (Preflight).*** Experiment AO054 consisted of two identical sets of hardware. One set was mounted in tray B4 and the other set was mounted in tray D10. Each set of hardware, which was self-contained within the experiment tray, consisted of six fiberglass-reinforced epoxy modules that carried charged dielectric samples on top and power supplies and electronics underneath. Four dielectric samples of Kapton film with vapor-deposited aluminum on one side (VDA-Kapton film) were bonded to each of the fiberglass modules with a silver-filled conductive epoxy adhesive. The spaces between the modules covered by dielectric samples and between the modules and the tray flanges were covered by strips of VDA-Kapton film attached with acrylic transfer adhesive and Kapton tape. In this photograph, reflections in the mirrorlike surfaces are visible. Each experiment tray also contained two solar cell modules.

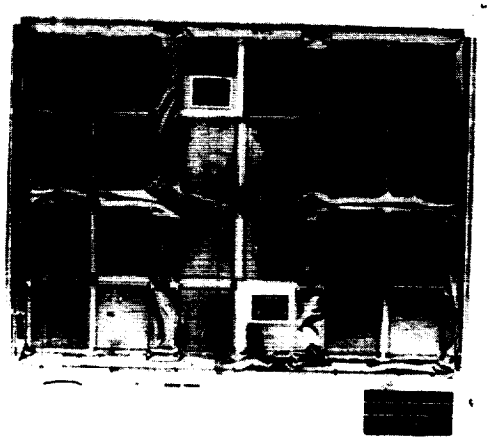

Figure 158
Photo No.: KSC-384C-221.04
Dup. Neg. No.: L84-7086
LISAR No.: EL-1994-00370
Photo Credit: KSC
Photo Date: 1/13/84
Location: KSC SAEF II
Subject: Preflight Survey of Tray B4

***Figure 159 (In Flight).*** The experiment appears to have no physical damage from exposure to the space environment. The lighting is such that changes in material colors are difficult to detect; however, the white paint in the vicinity of the solar cell modules appears to have darkened.

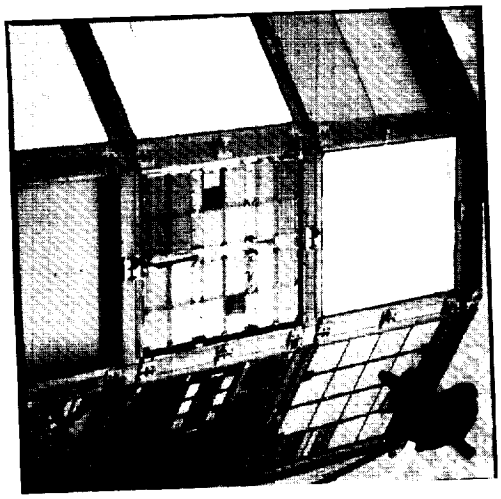

Figure 159
Photo No.: S32-77-027
Dup. Neg.: L90-10407
LISAR No.: EL-1994-00090
Photo Credit: JSC
Photo Date: 1/12/90
Location: In Flight
Subject: In-Flight Survey of Tray B4

***Figure 160 (Postflight).*** The experiment appears to be without physical damage. The white paint around the outer edges of the solar cell modules seems to have changed to a light tan.

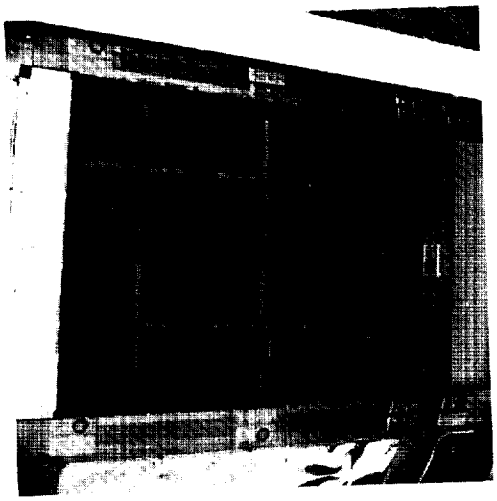

Figure 160
Photo No.: KSC-390C-730.08
Dup. Neg. No.: L92-17647
LISAR No.: EL-1994-00164
Photo Credit: KSC
Photo Date: 2/1/90
Location: KSC O & C building
Subject: Postflight Survey of Tray B4

***Figure 161 (Postflight).*** This photograph of the upper left one-sixth of the tray shows that the experiment has no apparent physical damage. Surfaces remain highly reflective.

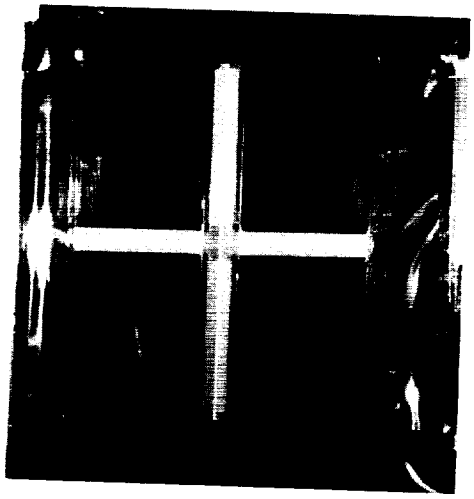

Figure 161
Photo No.: KSC-390C-2117.02
Dup Neg. No.: L91-7930
LISAR No.: EL-1994-00497
Photo Credit: KSC
Photo Date: 3/20/90
Location: KSC SAEF II
Subject: Postflight Detail of Upper Left of Tray B4

***Figure 162 (Postflight).*** This photograph of the upper center one-sixth of the tray shows that the experiment has no apparent physical damage. Surfaces remain highly reflective. The white paint around the outer edges of the solar cell modules appears to have changed to a light tan.

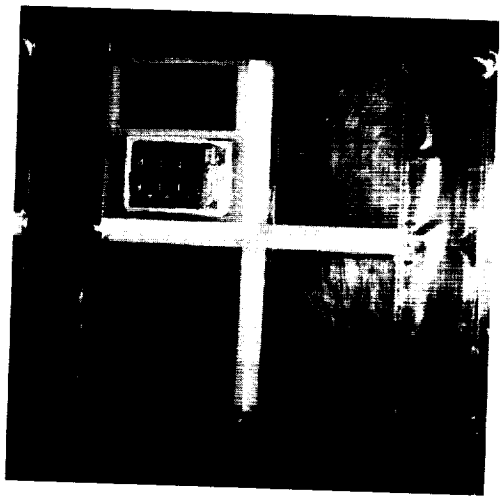

Figure 162
Photo No.: KSC-390C-2117.03
Dup. Neg. No.: L91-7931
LISAR No.: EL-1994-00498
Photo Credit: KSC
Photo Date: 3/20/90
Location: KSC SAEF II
Subject: Postflight Detail of Upper Center of Tray B4

***Figure 163 (Postflight).*** This photograph is of the upper right one-sixth of the tray. It shows the experiment with no apparent physical damage. Surfaces remain highly reflective.

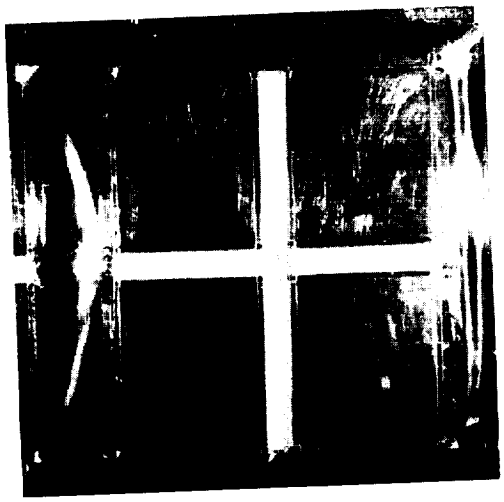

Figure 163
Photo No.: KSC-390C-2117.04
Dup. Neg. No.: L91-7932
LISAR No.: EL-1994-00499
Photo Credit: KSC
Photo Date: 3/20/90
Location: KSC SAEF II
Subject: Postflight Detail of Upper Right of Tray B4

***Figure 164 (Postflight).*** This photograph is of the lower left one-sixth of the tray. It shows the experiment with no apparent physical damage. Surfaces remain highly reflective.

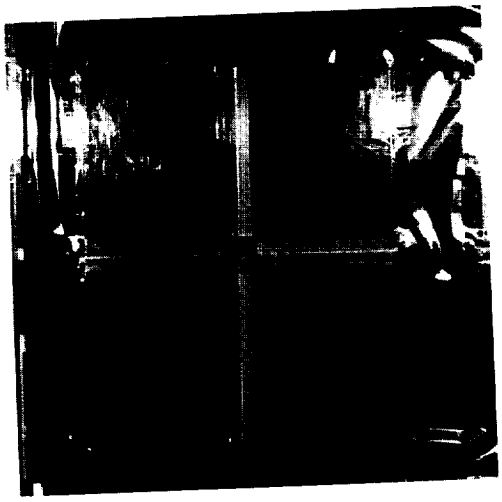

Figure 164
Photo No.: KSC-390C-2117.05
Dup. Neg. No.: L91-7933
LISAR No.: EL-1994-00500
Photo Credit: KSC
Photo Date: 3/20/90
Location: KSC SAEF II
Subject: Postflight Detail of Lower Left of Tray B4

***Figure 165 (Postflight).*** This photograph is of the lower center one-sixth of the tray. It shows the experiment with no apparent physical damage. Surfaces remain highly reflective. The white paint around the outer edges of the solar cell modules has changed to a light tan.

Figure 165
Photo No.: KSC-390C-2117.06
Dup. Neg. No.: L91-7934
LISAR No.: EL-1994-00501
Photo Credit: KSC
Photo Date: 3/20/90
Location: KSC SAEF II
Subject: Postflight Detail of Lower Center of Tray B4

***Figure 166 (Postflight).*** This photograph is of the lower right one-sixth of the tray. It shows the experiment without apparent physical damage. Surfaces remain highly reflective.

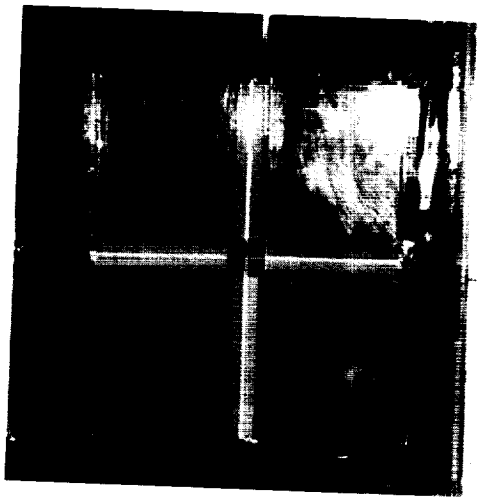

Figure 166
Photo No.: KSC-390C-2117.07
Dup. Neg. No.: L91-7935
LISAR No.: EL-1994-00502
Photo Credit: KSC
Photo Date: 3/20/90
Location: KSC SAEF II
Subject: Postflight Detail of Lower Right of Tray B4

## Tray B5

A High-Resolution Study of Ultraheavy Cosmic Ray Nuclei (UHCRE) (AO178)

Dublin Institute for Advanced Studies ESA at ESTEC

Trays: A2, A4, A10, B5, B7, C5, C6, C8, C11, D1, D5, D7, D11, E2, E10, and F4

See section entitled "Tray D5" and figure 319 for a typical preflight photograph of experiment AO178.

***Figure 167 (In Flight).*** The thermal cover has no apparent damage; however, it is more taut than in the prelaunch photograph. The glossy black appearance of the thermal cover is due to lighting conditions and not to a change in the material optical properties. The bright spots on the dark thermal cover background are areas where Velcro pads are bonded to the back of the cover. The large bright area on the left of the cover is reflected light.The scalloped edge across the top, bottom, and left side of the cover occurs between attachment pads. The ground strap is in place with no visible damage.

Figure 167
Photo No.: S32-76-107
Dup. Neg. No.: L90-10401
LISAR No.: EL-1994-00088
Photo Credit: JSC
Photo Date: 1/12/90
Location: In Flight
Subject: In-Flight Survey of Tray B5

***Figure 168 (Postflight).*** The thermal cover appears to be specular with no apparent damage. The cover is less taut than in the in-flight photograph and the locations of Velcro attachment pads are not as prominent. The scallop effect around the cover edges occurs between the attachment pads and shows the upper edge of the support frame. The ground strap is in place with no visible damage.

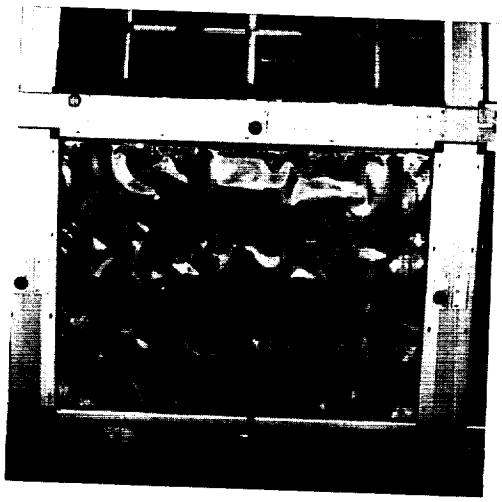

Figure 168
Photo No.: KSC-390C-1035.08
Dup. Neg. No.: L90-13453
LISAR No.: EL-1994-00184
Photo Credit: KSC
Photo Date: 2/9/90
Location: KSC SAEF II
Subject: Postflight Survey of Tray B5

***Figure 169 (Postflight).*** This photograph is of the upper left one-sixth of the tray. The thermal cover appears specular with no apparent damage. The reflective properties of the uneven surface of the cover result in various light and color patterns. A few impact or penetration discolorations are visible.

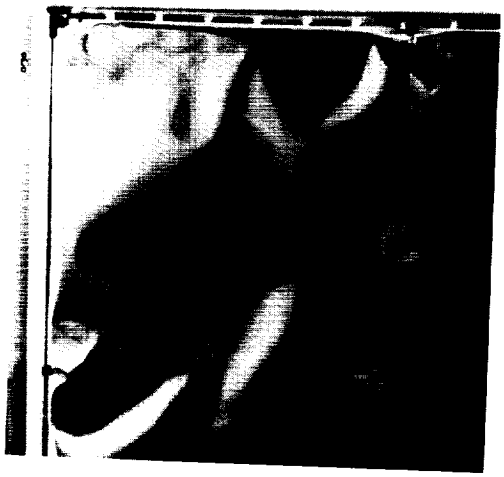

Figure 169
Photo No.: KSC-390C-2151.05
Dup. Neg. No.: L91-7974
LISAR No.: EL-1994-00513
Photo Credit: KSC
Photo Date: 3/21/90
Location: KSC SAEF II
Subject: Postflight Detail of Upper Left of Thermal Cover of Tray B5

***Figure 170 (Postflight).*** This photograph is of the upper center one-sixth of the tray. The thermal cover appears specular with no apparent damage. The reflective properties of the uneven surface of the cover result in various light and color patterns. A few impact or penetration discolorations are visible.

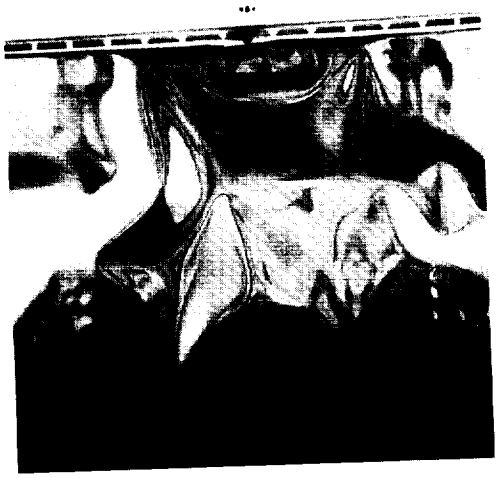

Figure 170
Photo No: KSC-390C-2151.06
Dup. Neg. No.: L91-7975
LISAR No.: EL-1994-00514
Photo Credit: KSC
Photo Date: 3/21/90
Location: KSC SAEF II
Subject: Postflight Detail of Upper Center of Thermal Cover of Tray B5

***Figure 171 (Postflight).*** This photograph is of the upper right one-sixth of the tray. The pattern enhanced by reflected light in the upper right corner of the thermal cover existed during preflight and was not due to space exposure. The thermal cover appears specular with no apparent damage. The reflective properties of the uneven surface of the cover result in various light and color patterns. A few impact or penetration discolorations are visible.

Figure 171
Photo No.: KSC-390C-2151.07
Dup. Neg. No.: L91-7976
LISAR No.: EL-1994-00515
Photo Credit: KSC
Photo Date: 3/21/90
Location: KSC SAEF II
Subject: Postflight Detail of Upper Right of Thermal Cover of Tray B5

***Figure 172 (Postflight).*** This photograph is of the lower left one-sixth of the tray. The thermal cover appears specular with no apparent damage. The reflective properties of the uneven surface of the cover result in various light and color patterns. A few impact or penetration discolorations are visible.

Figure 172
Photo No.: KSC-390C-2151.11
Dup. Neg. No.: L91-7980
LISAR No.: EL-1994-00516
Photo Credit: KSC
Photo Date: 3/21/90
Location: KSC SAEF II
Subject: Postflight Detail of Lower Left of Thermal Cover of Tray B5

***Figure 173 (Postflight).*** This photograph is of the lower center one-sixth of the tray. The thermal cover appears specular with no apparent damage. The reflective properties of the uneven surface of the cover result in various light and color patterns. A few impact or penetration discolorations are visible.

Figure 173
Photo No.: KSC-390C-2151.12
Dup. Neg. No.: L91-7981
LISAR No.: EL-1994-00517
Photo Credit: KSC
Photo Date: 3/21/90
Location: KSC SAEF II
Subject: Postflight Detail of Lower Center of Thermal Cover of Tray B5

***Figure 174 (Postflight).*** This photograph is of the lower right one-sixth of the tray. The pattern enhanced by reflected light along the right edge of the thermal cover existed preflight and was not due to space exposure. The thermal cover appears specular with no apparent damage. The reflective properties of the uneven surface of the cover result in various light and color patterns. A few impact or penetration discolorations are visible.

Figure 174
Photo No.: KSC-390C-2152.02
Dup. Neg. No.: L91-7983
LISAR No.: EL-1994-00518
Photo Credit: KSC
Photo Date: 3/21/90
Location: KSC SAEF II
Subject: Postflight Detail of Lower Right of Thermal Cover of Tray B5

## Tray B6

Space Debris Impact Experiment (S0001)

NASA LaRC

Trays: A5, A6, A12, B1, B2, B6, B8, B11, C4, C7, D2, D6, E1, E4, E7, E11, F1, F3, F5, F7, F10, F11, G4, G8, and H5

See section entitled "Tray A5" for a typical preflight photographic survey and experiment objective.

***Figure 175 (In Flight).*** A portion of the greenish-gray tint on the two debris panels is the product of the chromic anodization coating process; however, a large part can be attributed to reflections of the blue sky. The vertical streaks on the panels are products of chromic anodizing that have been enhanced significantly by the blue reflection. Fingerprints along the center edges of the debris panels occurred during experiment assembly and indicate improper preflight handling or cleaning.

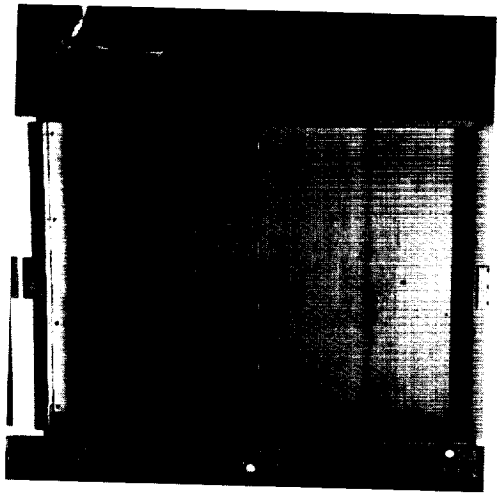

Figure 175
Photo No.: S32-76-105
Dup. Neg. No.: L90-10400
LISAR No.: EL-1994-00714
Photo Credit: JSC
Photo Date: 1/12/90
Location: In Flight
Subject: In-Flight Survey of Tray B6

***Figure 176 (Postflight).*** The pink and greenish-gray tints on the two debris panels are by-products of the chromic anodization coating process and are not attributed to contamination or exposure to the space environment. The fingerprints along the inner edges of the debris panels that were observed in the in-flight photograph are still visible. The dark vertical streaks on the debris panels in the in-flight photographs are almost invisible because the reflection of the sky is not present. The light band along the sides and across the bottom of the panels is caused by light reflecting from the tray sidewalls.

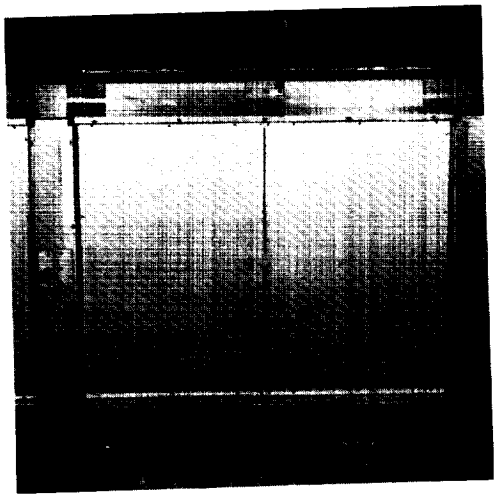

Figure 176
Photo No.: KSC-390C-1146.03
Dup. Neg. No.: L90-13505
LISAR No.: EL-1994-00192
Photo Credit: KSC
Photo Date: 2/18/90
Location: SAEF II at KSC
Subject: Postflight Survey of Tray B6

## Tray B7

A High-Resolution Study of Ultraheavy Cosmic Ray Nuclei (UHCRE) (AO178)

Dublin Institute for Advanced Studies ESA at ESTEC

Trays: A2, A4, A10, B5, B7, C5, C6, C8, C11, D1, D5, D7, D11, E2, E10, and F4

See section entitled "Tray D5" and figure 319 for a typical preflight photograph of experiment AO178.

***Figure 177 (In Flight).*** The thermal cover appears to have no apparent damage, but it is more taut than in the prelaunch photograph. The dark blue appearance of the thermal cover in this photograph is caused by lighting conditions and is not due to a change in the optical properties of the material. The oblong indentations on the thermal cover are areas where Velcro pads are bonded to the back of the cover. The surface of the thermal cover appears to have small brown circular discolorations of various sizes that appear to result from impacts or penetrations. A large light blue area of discoloration is clearly visible in the lower right quadrant of the thermal cover. The discoloration is probably the result of an impact penetrating the 5-mil Teflon film and upsetting the layer of vapor-deposited silver beneath. The scalloped edge along the left side of the thermal cover occurs between attachment pads. The ground strap appears to be in place with no visible damage, but it appears to be a deeper copper color than in the prelaunch photograph.

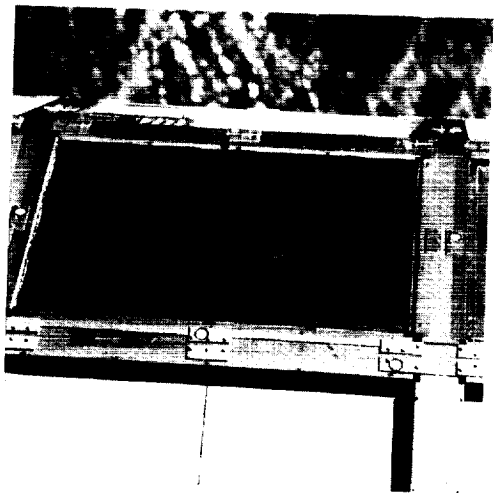

Figure 177
Photo No.: S32-76-101
Dup. Neg. No.: L90-10399
LISAR No.: EL-1994-00087
Photo Credit: JSC
Photo Date: 1/12/90
Location: In Flight
Subject: In-Flight Survey of Tray B7

***Figure 178 (Postflight).*** The surface of the thermal cover appears to have changed from specular to opaque with black dots of various sizes that appear to be impacts or penetrations. A large area of white discoloration is clearly visible in the upper left quadrant of the thermal cover. The discoloration is probably the result of a penetration of the 5-mil Teflon film that has affected the layer of vapor-deposited silver beneath. The cover is not as taut as in the in-flight photograph and the locations of Velcro attachment pads are not as prominent. The ground strap is in place with no visible damage, but it is a deeper copper color than in the prelaunch photograph.

Figure 178
Photo No.: KSC-390C-2306.09
Dup. Neg. No.: L91-8035
LISAR No.: EL-1994-00312
Photo Credit: KSC
Photo Date: 3/26/90
Location: KSC SAEF II
Subject: Postflight Survey of Tray B7

***Figure 179 (Postflight).*** This close-up photograph is of the upper left one-sixth of the tray. The thermal cover appears to be opaque rather than specular as it was in preflight photographs. Numerous impact or penetration discolorations are visible. The thermal cover Velcro tie-down pads are also evident.

Figure 179
Photo No.: KSC-390C-2306.10
Dup. Neg. No.: L91-8036
LISAR No.: EL-1994-00573
Photo Credit: KSC
Photo Date: 3/26/90
Location: KSC SAEF II
Subject: Postflight Detail of Upper Left of Thermal Cover of Tray B7

***Figure 180 (Postflight).*** This close-up photograph is of the upper center one-sixth of the tray. The thermal cover appears to be opaque rather than specular as it was in preflight photographs. Numerous impact or penetration discolorations are visible. The thermal cover Velcro tie-down pads are also evident.

Figure 180
Photo No.: KSC-390C-2306.11
Dup. Neg. No.: L91-8037
LISAR No.: EL-1994-00574
Photo Credit: KSC
Photo Date: 3/26/90
Location: KSC SAEF II
Subject: Postflight Detail of Upper Center of Thermal Cover of Tray B7

***Figure 181 (Postflight).*** This close-up photograph is of the upper right one-sixth of the tray. The thermal cover appears to be opaque rather than specular as it was in preflight photographs. Numerous impact or penetration discolorations are visible. The thermal cover Velcro tie-down pads are also evident.

Figure 181
Photo No.: KSC-390C-2306.12
Dup. Neg. No.: L91-8038
LISAR No.: EL-1994-00575
Photo Credit: KSC
Photo Date: 3/26/90
Location: KSC SAEF II
Subject: Postflight Detail of Upper Right of Thermal Cover of Tray B7

***Figure 182 (Postflight).*** This close-up photograph is of the lower left one-sixth of the tray. The thermal cover appears to be opaque rather than specular as it was in preflight photographs. Numerous impact or penetration discolorations are visible. The thermal cover Velcro tie-down pads are also evident.

Figure 182
Photo No.: KSC-390C-2307.05
Dup. Neg. No.: L91-8019
LISAR No.: EL-1994-00576
Photo Credit: KSC
Photo Date: 3/26/90
Location: KSC SAEF II
Subject: Postflight Detail of Lower Left of Thermal Cover of Tray B7

***Figure 183 (Postflight).*** This close-up photograph is of the lower center one-sixth of the tray. The thermal cover appears to be opaque rather than specular as it was in preflight photographs. Numerous impact or penetration discolorations are visible. The thermal cover Velcro tie-down pads are also evident.

Figure 183
Photo No.: KSC-390C-2307.06
Dup. Neg. No.: L91-8020
LISAR No.: EL-1994-00594
Photo Credit: KSC
Photo Date: 3/26/90
Location: KSC SAEF II
Subject: Postflight Detail of Lower Center of Thermal Cover of Tray B7

***Figure 184 (Postflight).*** This close-up photograph is of the lower right one-sixth of the tray. The thermal cover appears to be opaque rather than specular as it was in preflight photographs. Numerous impact or penetration discolorations are visible. The thermal cover Velcro tie-down pads are also evident.

Figure 184
Photo No.: KSC-390C-2307.07
Dup. Neg. No.: L91-8021
LISAR No.: EL-1994-00595
Photo Credit: KSC
Photo Date: 3/26/90
Location: KSC SAEF II
Subject: Postflight Detail of Lower Right of Tray B7

## Tray B8

Space Debris Impact Experiment (S0001)

NASA LaRC

Trays: A5, A6, A12, B1, B2, B6, B8, B11, C4, C7, D2, D6, E1, E4, E7, E11, F1, F3, F5, F7, F10, F11, G4, G8, and H5

See section entitled "Tray A5" for experiment objective.

Exposure to Space Radiation of High-Performance Infrared Multilayer Filters and Materials Technology Experiments (AO056)

University of Reading

British Aerospace Corporation

Trays: B8 and G12

The objectives of these experiments were to expose high-performance infrared multilayer filters and finishes and adhesive systems to the low-Earth-orbit space environment. The filters, finishes, and adhesive systems would then be measured to ascertain their suitability for use in spacecraft and to understand their degradation mechanisms.

Passive Exposure of Earth Radiation Budget Experiment Components (AO147)

The Eppley Laboratory, Inc.

Trays: B8 and G12

The objective of this experiment was to expose channel components of Earth Radiation Budget Experiment to the space environment and then to submit the components to radiometric calibration. This experiment intended to apply corrections to results from the Earth Radiation Budget Experiment and to use the information in the selection of components for future solar and Earth radiation budget experiments.

***Figure 185 (Preflight).*** Experiment AO056, located in the upper right, was made up of 46 individual specimens divided between 2 experiment modules (tray B8 and tray G12). The infrared filters and coating samples were in the circular holders, which were located in the left of the module, and the materials technology samples were located in the right.

Experiment AO147 was divided between two modules. The module that contained solar channel components was located in this tray. A second module that contained three Earth flux channel components was located in tray G12. Experiment AO147, located in the lower right corner, consisted of 10 solar sensors (in a Nimbus ERB solar array block in the center of the experiment module) and 10 interference filters (in the circular holders above and below the solar sensors). The mounting plate exterior surface, the infrared filter holders, and the curved surface of the Nimbus ERB solar array block were painted white to fulfill thermal control requirements. Because the mounting surface of tray B8 faced 30° off the leading edge of LDEF, the Nimbus solar array block was tilted 30° to face forward to provide a sun view similar to the ERB Experiment on Nimbus.

Experiment S0001, which was mounted in the left two-thirds of the tray, consisted of two 3/16-in-thick chromic-anodized aluminum panels; it displays the familiar green and pink that is caused by anodization.

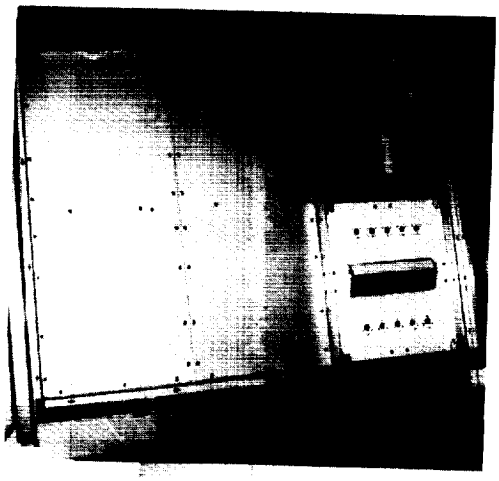

Figure 185
Photo No.: KSC-384C-294.07
Dup. Neg. No.: L84-7116
LISAR No.: EL-1994-00384
Photo Credit: KSC
Photo Date: 1/19/84
Location: KSC SAEF II
Subject: Preflight Survey of Tray B8

***Figure 186 (In Flight).*** Here, the space debris impact panels have a very distinct green and pink color that varies as the light angle changes across the panels. The different colors of the infrared filter surfaces of experiment AO056 may be reflections of the surrounding environment and are not from exposure to space. A brown discoloration is present on the surface of the unpainted aluminum mounting plate. Experiment AO147 appears to have no physical damage. The white paint on the aluminum mounting plate has several irregular-shaped black marks along the top edge. The marks were not visible on the prelaunch photograph.

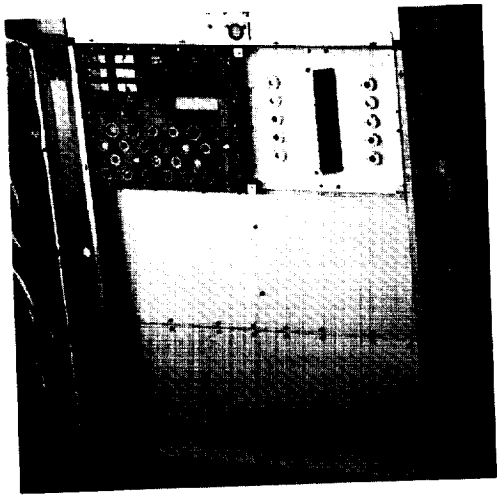

Figure 186
Photo No.: S32-76-026
Dup. Neg. No.: L90-10380
LISAR No.: EL-1994-00665
Photo Credit: JSC
Photo Date: 1/12/90
Location: In Flight
Subject: In-Flight Survey of Tray B8

***Figure 187 (Postflight).*** Experiment AO056 appears unchanged from the in-flight photograph. The apparent blue, green, silver, and white colors of coatings and filter samples observed in the in-flight photographs are not visible. A brown discoloration is present on the surface of the unpainted aluminum mounting plate. The discoloration is darker near the fasteners around the mounting plate edges and the filter and coating holders. Experiment AO147, which is located in the lower right of the tray, appears to be without physical damage. Experiment S0001 shows the familiar green and pink that is caused by anodization.

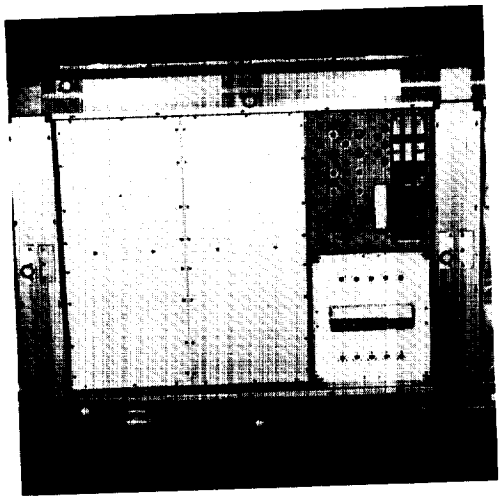

Figure 187
Photo No.: KSC-390C-1031.11
Dup. Neg. No.: L90-13421
LISAR No.: EL-1994-00146
Photo Credit: KSC
Photo Date: 2/9/90
Location: KSC SAEF II
Subject: Postflight Survey of Tray B8

***Figure 188 (Postflight).*** This photograph is of the upper left one-fourth of the module for experiment AO056. The experiment is intact, but has sustained some physical damage. The experiment sample located in the second circular holder from the top in the right row appears to be missing. A brown discoloration is present on the surface of the unpainted aluminum mounting plate. The discoloration is darker near the fasteners around the mounting plate edges and the filter and coating holders.

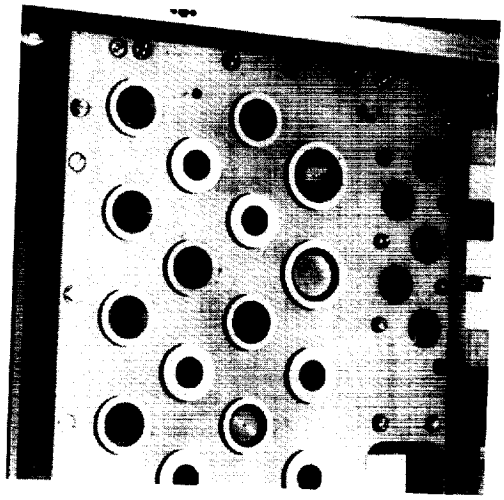

Figure 188
Photo No.: KSC-390C-1931.09
Dup. Neg. No.: L91-8064
LISAR No.: EL-1994-00431
Photo Credit: KSC
Photo Date: 3/14/90
Location: KSC SAEF II
Subject: Postflight Detail of Upper Right of Tray B8

***Figure 189 (Postflight).*** This photograph is of the lower left one-fourth of the module for experiment AO056. The experiment has sustained some physical damage. An impact crater and two cracks extending outward from the crater are visible in the experiment sample mounted in the second circular holder from the bottom in the right row of filter and coating samples. A brown discoloration is present on the surface of the unpainted aluminum mounting plate and near the filter and coating holders.

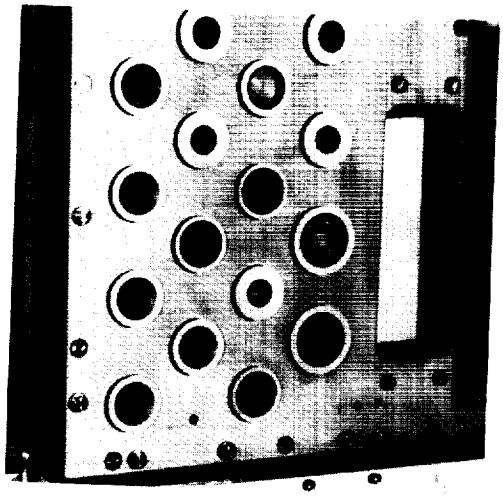

Figure 189
Photo No.: KSC-390C-1931.10
Dup. Neg.: L91-8065
LISAR No.: EL-1994-00432
Photo Credit: KSC
Photo Date: 3/14/90
Location: KSC SAEF II
Subject: Postflight Detail of Upper Right of Tray B8

***Figure 190 (Postflight).*** This photograph is of the upper right one-fourth of the module for experiment AO056. The experiment is intact, but brown discolorations appear on surfaces of the Materials Technology Experiment samples that are mounted in the right half of the module.

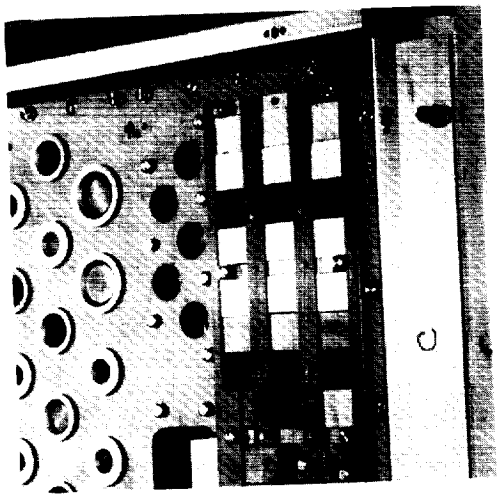

Figure 190
Photo No.: KSC-390C-1931.11
Dup. Neg. No.: L91-8066
LISAR No.: EL-1994-00433
Photo Credit: KSC
Photo Date: 3/14/90
Location: KSC SAEF II
Subject: Postflight Detail of Upper Right of Tray B8

***Figure 191 (Postflight).*** This photograph is of the lower right one-fourth of the module for experiment AO056. The experiment is intact, but brown discolorations appear on surfaces of the Materials Technology Experiment samples that are mounted in the right half of the module.

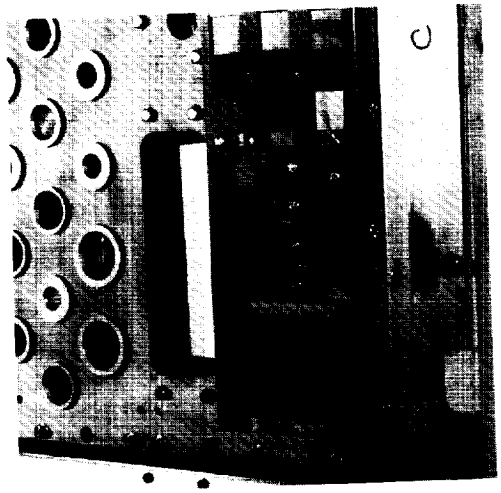

Figure 191
Photo No.: KSC-390C-1931.12
Dup. Neg. No.: L91-8067
LISAR No.: EL-1994-00434
Photo Credit: KSC
Photo Date: 3/14/90
Location: KSC SAEF II
Subject: Postflight Detail of Lower Right of Tray B8

## Tray B9

Space Exposure of Composite Materials for Large Space Structures (CMLSS) (AO134)

NASA LaRC

Tray: B9

The objective of this experiment was to evaluate the chemical and physical properties of selected graphite-fiber-reinforced epoxy and polysulfone matrix resin composites materials exposed to the low Earth environment (atomic oxygen, ultraviolet and particulate radiation, meteoroids and debris, and vacuum and temperature cycling).

Exposure of Spacecraft Coatings (ESC) (S0010)

NASA LaRC

Tray: B9

The objectives of this experiment were to determine the effects of both the environment induced by the Shuttle and the space radiation environment on selected sets of spacecraft materials and thermal control coatings.

***Figure 192 (Preflight).*** Experiment AO134 consisted of graphite-epoxy and polysulfone-graphite tensile specimens. Some specimens were coated with sputtered-metal deposits to evaluate the effectiveness of metals in protecting the composites when exposed to atomic oxygen. Twelve specimens, six composite that were located near the top edge and six metal that were located near the bottom edge of the support plate, were late additions and were attached to the support plate with safety wire. An identical set of test specimens mounted on the back of the support plate was exposed to only the temperature cycling and the vacuum environment. Sixteen coated composite samples and 14 thin polymeric and resin films were on the mounting plate in the upper center tray center. Forty-eight coated composite specimens were mounted in the center of the tray and partially masked with a thin aluminum cover plate with circular openings. Experiment S0010 consisted of two parts: one set of test specimens was located in the lower half of the tray center section and a second set of test specimens was in an EECC located in the right section of the experiment tray.

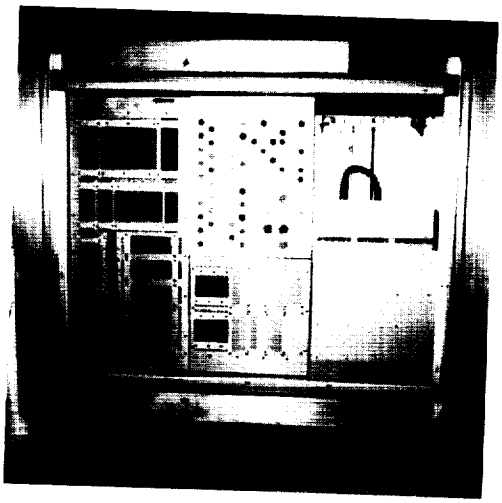

Figure 192
Photo No.: KSC-384C-59.01
Dup. Neg. No.: L84-7027
LISAR No.: EL-1994-00344
Photo Credit: KSC
Photo Date: 1/17/84
Location: KSC SAEF II
Subject: Preflight Survey of Tray B9

***Figure 193 (In Flight).*** In this photograph, the top and lower flanges have abrasions from prelaunch testing. Experiment AO147 component, located on the upper one-third of the tray mounting plate, is intact and the mounting hardware appears secure. Much of the mounting hardware is discolored. In the left center, only a few fragments of the 14 polymeric and resin thin-film materials have survived the mission.

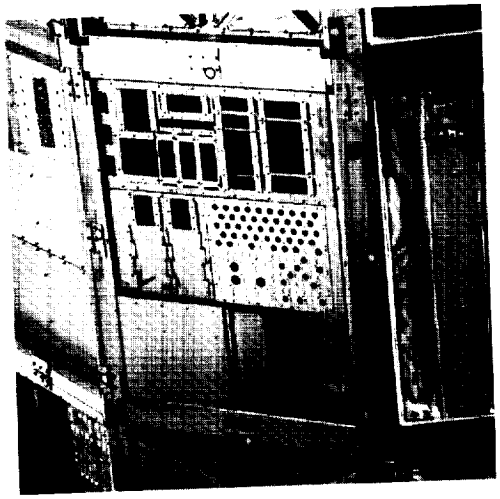

Figure 193
Photo No.: S32-76-001
Dup. Neg. No.: L90-10374
LISAR No.: EL-1994-00659
Photo Credit: JSC
Photo Date: 1/12/90
Location: In Flight
Subject: In-Flight Survey of Tray B9

***Figure 194 (Postflight).*** The right and left flanges and each end of the top flange of the tray have abrasions from prelaunch testing. Most test specimens are intact except in the upper left center one-third where many thin films are damaged or missing. Mounting hardware is discolored. The EECC located in the left section of the experiment tray has a dark brown discoloration on the mounting structure in the bottom of the tray.

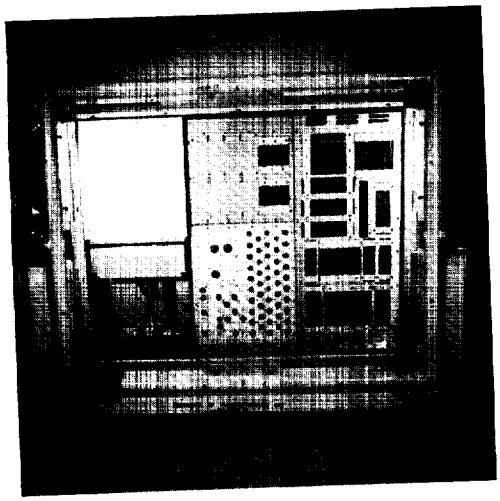

Figure 194
Photo No.: KSC-390C-1913.09
Dup. Neg. No.: L91-2536
LISAR No.: EL-1994-00281
Photo Credit: KSC
Photo Date: 3/13/90
Location: KSC SAEF II
Subject: Postflight Survey of Tray B9

***Figure 195 (Postflight).*** This photograph of the upper center one-sixth of the tray shows that thin-film test specimens are missing. There is a brown discoloration at the upper left corner of the baseplate.

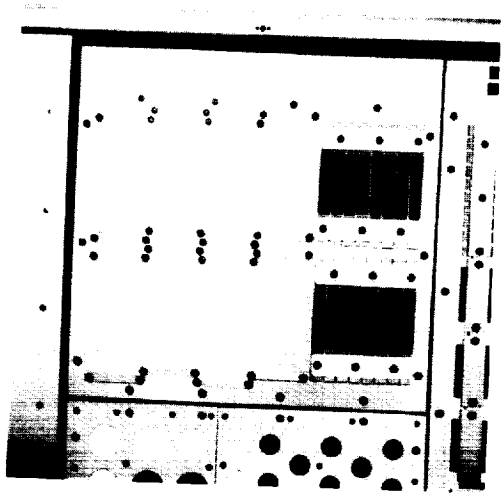

Figure 195
Photo No. KSC-390C-1913.11
Dup. Neg. No.: L91-2538
LISAR No.: EL-1994-00419
Photo Credit: KSC
Photo Date: 3/13/90
Location: KSC SAEF II
Subject: Postflight Detail of Upper Center of Tray B9

***Figure 196 (Postflight).*** This photograph of the upper right one-sixth of the tray shows that the test specimens are intact. However, some specimens are somewhat discolored and some have diagonal markings and patterns.

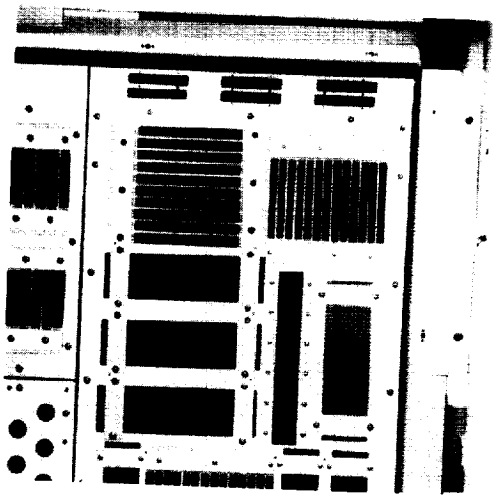

Figure 196
Photo No.: KSC-390C-1913.12
Dup. Neg. No.: L91-2539
LISAR No.: EL-1994-00420
Photo Credit: KSC
Photo Date: 3/13/90
Location: KSC SAEF II
Subject: Postflight Detail of Upper Right of Tray B9

***Figure 197 (Postflight).*** This photograph of the lower center one-sixth of the tray shows that some test specimens have changed color and some appear damaged.

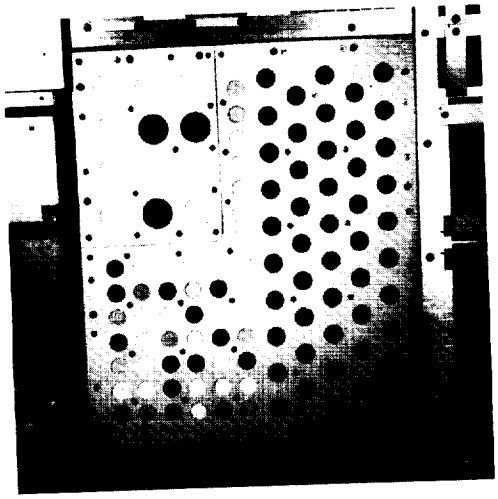

Figure 197
Photo No.: KSC-390C-1914.03
Dup. Neg. No.: L91-8108
LISAR No.: EL-1994-00421
Photo Credit: KSC
Photo Date: 3/13/90
Location: KSC SAEF II
Subject: Postflight Detail of Lower Center of Tray B9

***Figure 198 (Postflight).*** This photograph of the lower right one-sixth of the tray shows that the test specimens are intact, but some are discolored and some have diagonal markings and patterns.

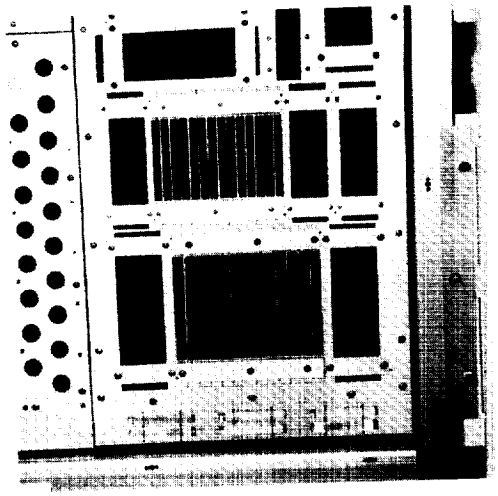

Figure 198
Photo No.: KSC-390C-1914.04
Dup. Neg. No.: L91-8109
LISAR No.: EL-1994-00422
Photo Credit: KSC
Photo Date: 3/13/90
Location: KSC SAEF II
Subject: Postflight Detail of Lower Right of Tray B9

***Figure 199 (Postflight).*** This close-up photograph shows the general discoloration of a group of test specimens in the upper right of the tray.

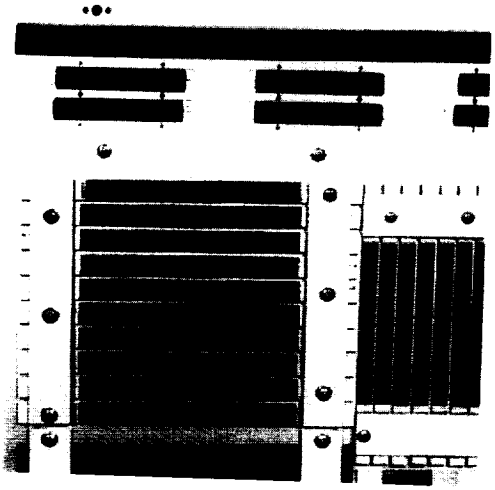

Figure 199
Photo No.: KSC-390C-1914.11
Dup. Neg. No.: L91-8116
LISAR No.: EL-1994-00423
Photo Credit: KSC
Photo Date: 3/13/90
Location: KSC SAEF II
Subject: Postflight Detail of Upper Right of Tray B9

***Figure 200 (Postflight).*** This close-up photograph shows the general discoloration of a group of test specimens in the upper right of the tray.

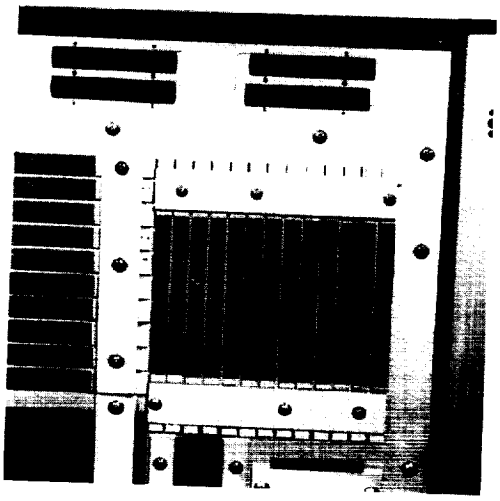

Figure 200
Photo No.: KSC-390C-1914.12
Dup. Neg. No.: L91-8117
LISAR No.: EL-1994-00424
Photo Credit: KSC
Photo Date: 3/13/90
Location: KSC SAEF II
Subject: Postflight Detail of Upper Right of Tray B9

***Figure 201 (Postflight).*** This close-up photograph shows the general discoloration of a group of test specimens in the lower right of the tray.

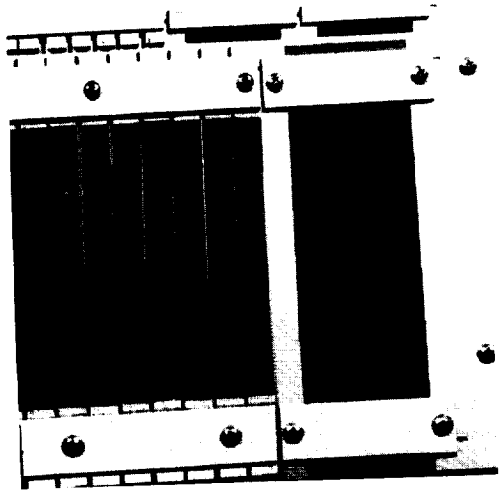

Figure 201
Photo No.: KSC-390C-1916.02
Dup. Neg. No.: L91-8083
LISAR No.: EL-1994-00425
Photo Credit: KSC
Photo Date: 3/13/90
Location: KSC SAEF II
Subject: Postflight Detail of Lower Right of B9

## Tray B10

Transverse Flat-Plate Heat Pipe Experiment (S1005)

NASA MSFC Grumman Aerospace Corporation

Tray: B10

The objective of this experiment was to evaluate the 0-$g$ performance of a number of transverse flat-plate heat pipe modules. There was no preflight photograph taken.

***Figure 202 (In Flight).*** The experiment consisted of three transverse flat-plate heat pipe modules, a power system for the heaters, a data acquisition and storage system, and an aluminum support structure. The surface of the experiment that was exposed to the space environment consisted of the exterior surfaces of the three heat pipe modules and silvered Teflon film. Thermal blankets covered the aluminum mounting hardware and openings between the hardware and the tray sidewalls. The raised surface at the end of each heat pipe module contained the fluid reservoir. The specular surface of the silvered Teflon film has become diffuse and appears white with numerous impact craters; black specks are visible on the white surfaces. Some areas of pronounced discoloration are visible.

Figure 202
Photo No.: S32-78-076
Dup. Neg. No.: L90-10444
LISAR No.: EL-1994-00017
Photo Credit: JSC
Photo Date: 1/12/90
Location: In Flight
Subject: In-Flight Survey of Tray B10

***Figure 203 (Postflight).*** The thermal blanket with the patches across the lower edge of the photograph was part of the RMS thermal cover and was not associated with the experiment S1002. The specular surface of the silvered Teflon film has become diffuse and appears white. Numerous impact craters, black specks, and other discolorations are visible.

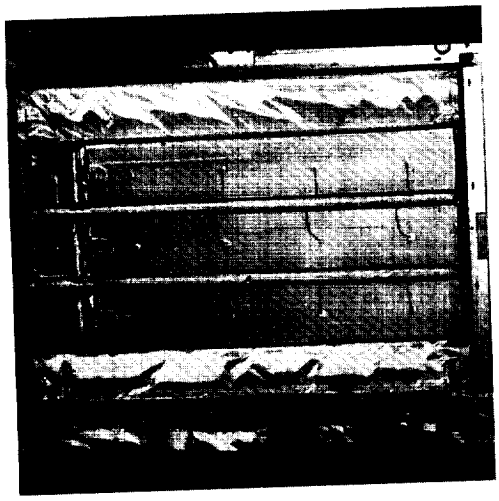

Figure 203
Photo No.: KSC-390C-612.02
Dup. Neg. No.: L92-17793
LISAR No.: EL-1994-00123
Photo Credit: KSC
Photo Date: 1/30/90
Location: KSC OPF
Subject: Postflight Survey of Tray B10

***Figure 204 (Postflight).*** This photograph of the left of the tray shows that the silvered Teflon film now appears diffuse. Space debris impacts appear as small black dots.

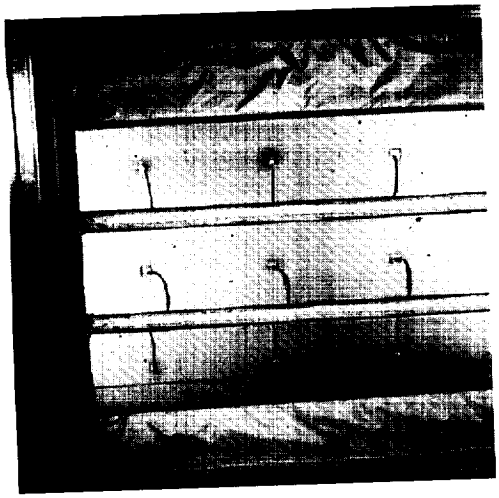

Figure 204
Photo No.: KSC-390C-1413.09
Dup. Neg. No.: L91-8987
LISAR No.: EL-1994-00363
Photo Credit: KSC
Photo Date: 3/1/90
Location: KSC SAEF II
Subject: Postflight Detail of the Left of Tray B10

***Figure 205 (Postflight).*** This photograph of the right of the tray shows that the silvered Teflon film now appears diffuse. Space debris impacts appear as small black dots. There is an area of brown discoloration on the right end of the center heat pipe module.

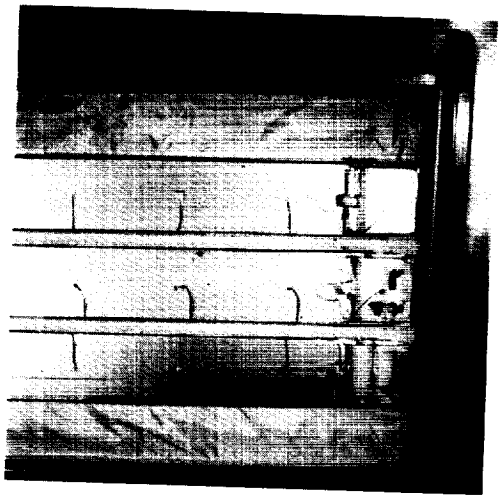

Figure 205
Photo No.: KSC-390C-1413.10
Dup. Neg. No.: L91-8988
LISAR No.: EL-1994-00347
Photo Credit: KSC
Photo Date: 3/1/90
Location: KSC SAEF II
Subject: Postflight Detail of Right Side of Tray B10

***Figure 206 (Postflight).*** This photograph of the lower left of the tray shows that the silvered Teflon film now appears diffuse. Space debris impacts appear as small black dots.

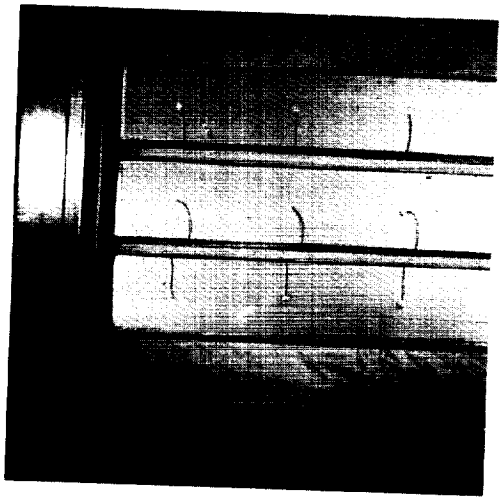

Figure 206
Photo No.: KSC-390C-1413.11
Dup. Neg. No.: L91-8989
LISAR No.: EL-1994-00348
Photo Credit: KSC
Photo Date: 3/1/90
Location: KSC SAEF II
Subject: Postflight Detail of Lower Left of Tray B10

***Figure 207 (Postflight).*** This photograph of the lower right of the tray shows that the silvered Teflon film now appears diffuse. Space debris impacts appear as small black dots. There is an area of brown discoloration on the right end of the center heat pipe module.

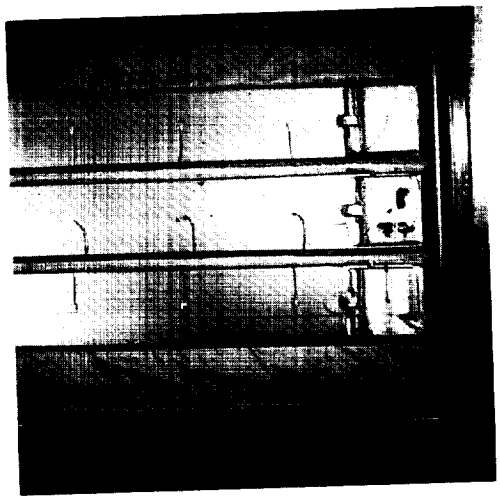

Figure 207
Photo No.: KSC-390C-1413.12
Dup. Neg. No.: L91-8990
LISAR No.: EL-1994-00349
Photo Credit: KSC
Photo Date: 3/1/90
Location: KSC SAEF II
Subject: Postflight Detail of Lower Right of Tray B10

***Figure 208 (Postflight).*** This close-up photograph is of the discolored area on the right end of the center heat pipe module.

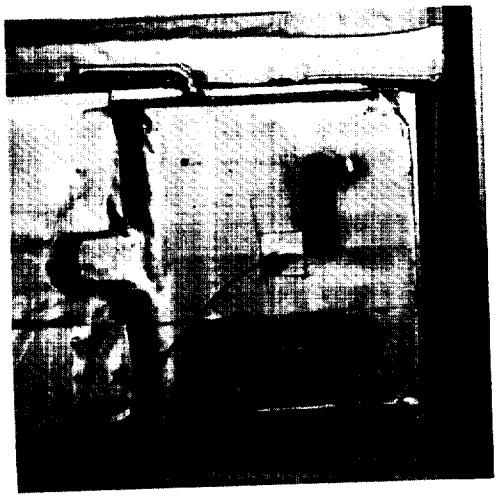

Figure 208
Photo No.: KSC-390C-1414.04
Dup. Neg. No.: L91-8171
LISAR No.: EL-1994-00350
Photo Credit: KSC
Photo Date: 3/1/90
Location: KSC SAEF II
Subject: Postflight Detail of Discoloration on Center Heat Pipe Module in Tray B10

## Tray B11

Space Debris Impact Experiment (S0001)

NASA LaRC

Trays: A5, A6, A12, B1, B2, B6, B8, B11, C4, C7, D2, D6, E1, E4, E7, E11, F1, F3, F5, F7, F10, F11, G4, G8, and H5

See section entitled "Tray A5" for a typical preflight photographic survey and experiment objective.

***Figure 209 (In Flight).*** The discolorations on the lower left sidewall of the experiment tray appear to be fingerprints from prelaunch handling. A portion of the pink and greenish-gray tint on the two debris panels are by-products of the chromic anodize coating process; however, part of the intensity can be attributed to reflections of the blue sky. The vertical streaks on the right debris panel are by-products of chromic anodizing that have been enhanced by the blue reflection. A light irregular discoloration is visible on the left debris panel; it starts near the center of the left edge and progresses down and to the right. The light band along the vertical edge of the left debris panel is a reflection from the tray sidewall.

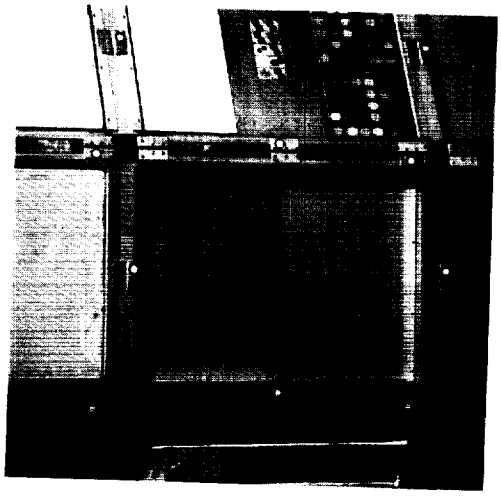

Figure 209
Photo No.: S32-78-038
Dup. Neg. No.: L90-10433
LISAR No.: EL-1994-00009
Photo Credit: JSC
Photo Date: 1/12/90
Location: In Flight
Subject: In-Flight Survey of Tray B11

***Figure 210 (Postflight).*** The postflight photograph was taken in the SAEF II at KSC prior to the removal of the experiment from the LDEF. The pink and greenish-gray tints on the two debris panels are by-products of the chromic anodize coating process and are not attributed to contamination or exposure to the space environment. The dark streaks observed on the right debris panel in the in-flight photograph are no longer visible because the reflection of the sky is not present. However, the light irregular discoloration starting near the center of the left edge is clearly visible on the left debris panel. The light band along the sides and across the bottom of the panels is caused by light reflecting from the tray sidewall.

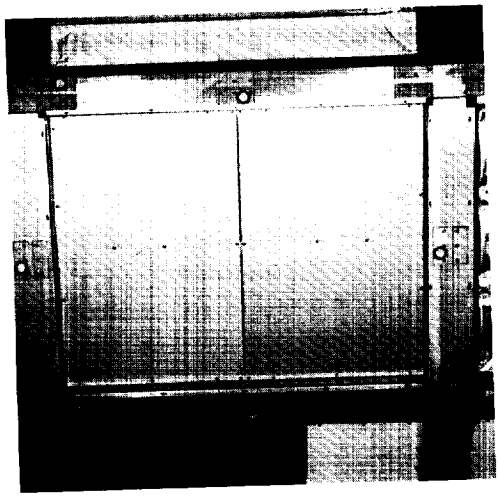

Figure 210
Photo No.: KSC-390C-1028.07
Dup. Neg. No.: L90-13381
LISAR No.: EL-1994-00141
Photo Credit: KSC
Photo Date: 2/9/90
Location: KSC SAEF II
Subject: Postflight Survey of Tray B11

## Tray B12

Interplanetary Dust Experiment (IDE) (AO201)

Institute for Space Science and Technology

NASA LaRC

North Carolina State University

Trays: B12, C3, C9, D6, G10, and H11

The objective of this experiment was to study interplanetary dust and obtain information about particle mass and velocity.

***Figure 211 (Preflight).*** Experiment AO201 exposed 80 metal-oxide-silicon (MOS) capacitor-type impact sensors and 1 solar sensor. The visible surface of the impact sensor was a vapor deposition of 1000 A of aluminum on a $SiO_2$ surface on a 250-μm-thick silicon wafer. The complete wafers, IDE detectors, were bonded to chromic-anodized aluminum frames with a space-qualified devolitized silicon adhesive. The solar sensor consisted of four silicon solar cells connected in series with the associated circuitry, which was bonded to an aluminum base-plate. The impact sensors were mounted in the left one-third of the tray. The solar sensor was mounted in the center of the sensor panel.

The center one-third of the tray cover was a chromic-anodized aluminum plate that protected the electronics mounted underneath. It also served as a mounting platform for 10 individual specimen holders. The material specimens were bonded to the holders with a silicon adhesive.

The cover plate in the right one-third was the aluminum EPDS cover plate painted with Chemglaze II A-276 white paint. The EPDS accommodated all six trays of this experiment. This preflight photograph shows reflections of the surroundings in the metallized surfaces.

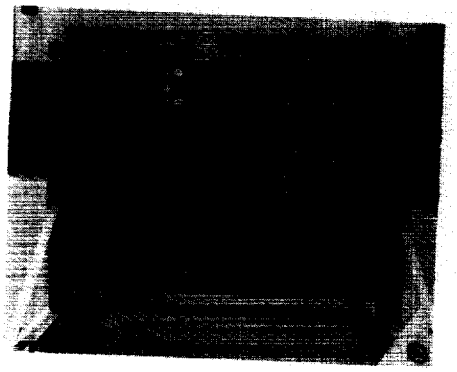

Figure 211
Photo No.: KSC-384C-14.02
Dup. Neg. No.: L84-7004
LISAR No.: EL-1994-00329
Photo Credit: KSC
Photo Date: 1/9/84
Location: KSC SAEF II
Subject: Preflight Survey of Tray B12

***Figure 212 (In Flight).*** The in-flight photograph is covered by the shadow from the orbiter RMS arm and cannot be readily compared with the preflight photograph. The surface area that can be observed does not seem to be significantly degraded.

Figure 212
Photo No.: S32-78-026
Dup. Neg. No.: L90-10429
LISAR No.: EL-1994-00005
Photo Credit: JSC
Photo Date: 1/12/90
Location: In Flight
Subject: In-Flight Survey of Tray B12

***Figure 213 (Postflight).*** The postflight photograph shows little change to the exposed surfaces when compared with the preflight photograph. Although not noticeable in the photograph, a light coating of contamination was visible on all experiment surfaces in this location. The difference in the colors of the IDE detectors that are located on the left mounting plate is a result of the reflected surroundings and is not related to space exposure. The EPDS thermal cover on the right side of the tray shows a light coating of brown contamination on the Chemglaze II A-276 white paint. Markings along the top of the photograph are due to film processing.

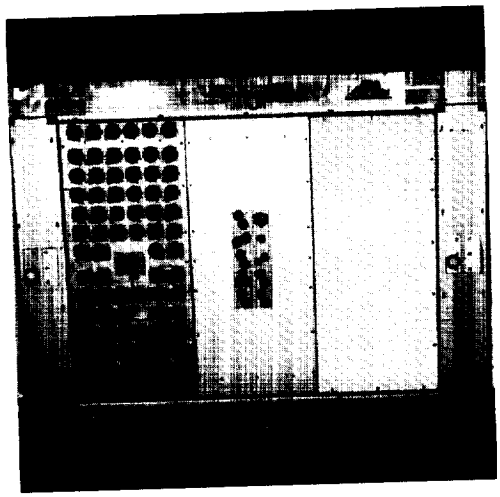

Figure 213
Photo No.: KSC-390C-1069.12
Dup. Neg. No.: L90-13492
LISAR No.: EL-1994-00204
Photo Credit: KSC
Photo Date: 2/8/90
Location: KSC SAEF II
Subject: Postflight Survey of Tray B12

***Figure 214 (Postflight).*** This photograph is of the upper left one-sixth of the tray. The difference in the colors of the IDE detectors is a result of the reflected surroundings and is not related to space exposure. The solar sensor located near the bottom of the photograph has changed little. The color of the solar array baseplate shows indications of contamination and appears to be darker than the detector mounting plate. A close observation of the detector surfaces reveals that some damage has occurred from meteoroid or debris impacts. One impact crater is visible on the detector located in the sixth row down from the top and the fifth row from the left. Other impacts, smaller in size, show as small white dots on the surface of the detectors.

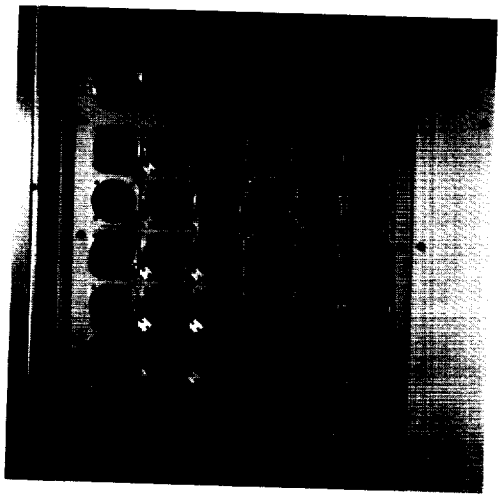

Figure 214
Photo No.: KSC-390C-1737.10
Dup. Neg. No.: L91-8189
LISAR No.: EL-1994-00234
Photo Credit: KSC
Photo Date: 3/8/90
Location: KSC SAEF II
Subject: Postflight Detail of Upper Left of Tray B12

***Figure 215 (Postflight).*** This photograph is of the upper center one-sixth of the tray. The center section cover plate shows little change except that a light coat of brown contamination can be observed on all surfaces. The color of the bonding material, which was used to secure several thin sapphire specimens to individual mounting plates at the bottom of the photograph, has changed from pink to gold. For one specimen, the bonding material is more gray than gold in color. This color difference has been attributed to the specimen being considerably thicker.

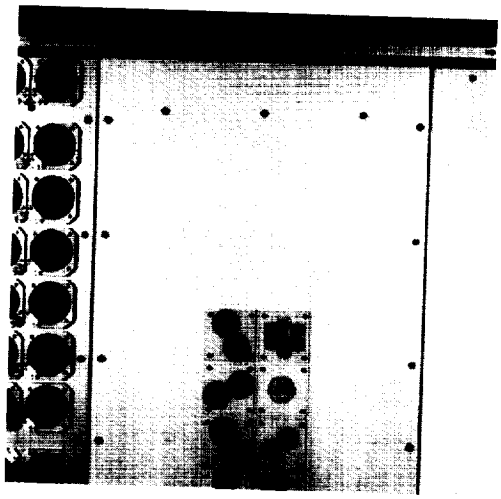

Figure 215
Photo No.: KSC-390C-1737.11
Dup. Neg. No.: L91-8190
LISAR No.: EL-1994-00235
Photo Credit: KSC
Photo Date: 3/8/90
Location: KSC SAEF II
Subject: Postflight Detail of Upper Center of Tray B12

***Figure 216 (Postflight).*** This close-up photograph is of the upper left one-sixth of the tray. The different colors of the impact detectors are caused by reflections of the surroundings. There are some space debris impact craters visible on some sensors. A large impact crater is visible on the sensor located second from the right in the bottom row. There also appear to be areas of discoloration or contamination around the edges of some sensors.

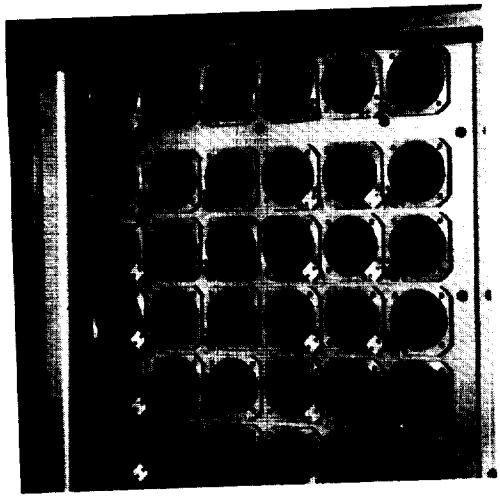

Figure 216
Photo No.: KSC-390C-1739.06
Dup. Neg. No.: L91-8197
LISAR No.: EL-1994-00236
Photo Credit: KSC
Photo Date: 3/8/90
Location: KSC SAEF II
Subject: Close-up of Upper Left of Tray B12

***Figure 217 (Postflight).*** This photograph is of the center left one-third of the tray. Space debris impact craters are visible on some of the sensors. The different colors of the impact detectors are caused by reflections of the surroundings. Some reflections of room surroundings are visible in sensors in the left row. There also are areas of discoloration or contamination on or around the edges of some sensors. The solar sensor located near the bottom of the photograph has changed little. The color of the solar array baseplate shows indications of contamination and is a little darker than the detector mounting plate.

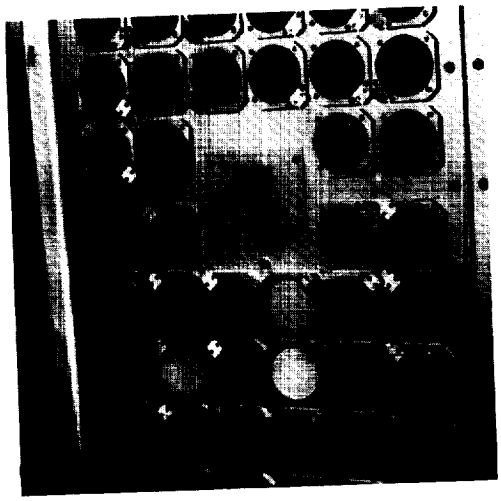

Figure 217
Photo No.: KSC-390C-1739.07
Dup. Neg. No.: L91-8198
LISAR No.: EL-1994-00237
Photo Credit: KSC
Photo Date: 3/8/90
Location: KSC SAEF II
Subject: Postflight Detail of Center Left of Tray B12

***Figure 218 (Postflight).*** This photograph is of the lower left one-sixth of the tray. Space debris impact craters are visible on some of the sensors. There also appear to be areas of discoloration or contamination on or around the edges of some sensors. The different colors of the impact detectors are caused by reflections of the surroundings.

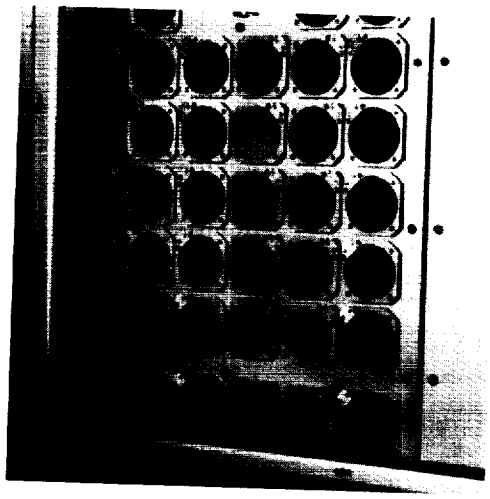

Figure 218
Photo No.: KSC-390C-1739.08
Dup. Neg. No.: L91-8199
LISAR No.: EL-1994-00238
Photo Credit: KSC
Photo Date: 3/8/90
Location: KSC SAEF II
Subject: Postflight Detail of Lower Left of Tray B12

***Figure 219 (Postflight).*** This close-up photograph is of a sensor and shows a space debris impact crater. This sensor is the second from the right in the second row from the bottom in the photograph shown in figure 218. Other small impacts are also visible.

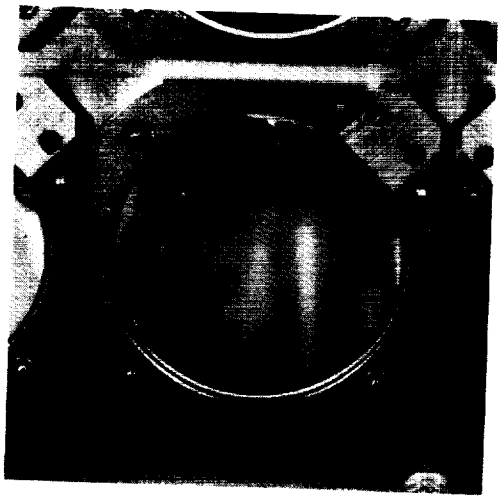

Figure 219
Photo No.: KSC-390C-1739.10
Dup. Neg. No.: L91-8201
LISAR No.: EL-1994-00239
Photo Credit: KSC
Photo Date: 3/8/90
Location: KSC SAEF II
Subject: Postflight Detail of Sensor on Tray B12

## Tray C1

This tray contained the grapple that was used by the RMS to deploy and to retrieve the LDEF.

***Figure 220 (Preflight).*** The tray assembly consisted of a modified 6-in-deep experiment tray, a chromic-anodized aluminum mounting plate, and a standard mechanical grapple fixture provided by JSC. Two aluminum plates, one in the upper left corner and one near the right center of the tray, covered access openings in the mounting plate. The black chevrons painted on the left side of the mounting plate were used for tray identification. The camera target (black with white markings) was attached to the right edge of the grapple fixture to assist the operator in positioning the RMS end effecter during retrieval operations.

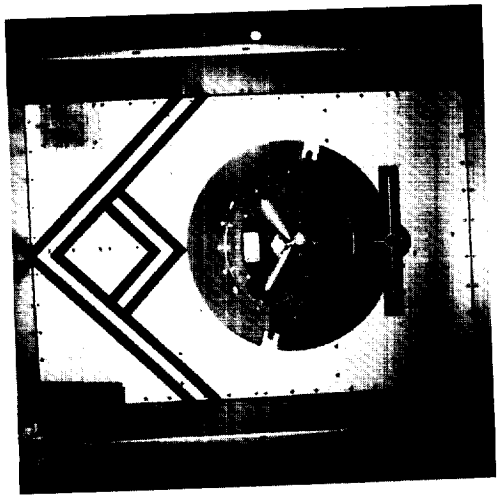

Figure 220
Photo No.: KSC-383C-4418.04
Dup. Neg. No.: L84-7312
LISAR No.: EL-1994-00328
Photo Credit: KSC
Photo Date: 12/8/83
Location: KSC SAEF II
Subject: Preflight Survey of Tray C1

***Figure 221 (In Flight).*** The grapple tray assembly appears to be without physical damage. The camera on the RMS end effecter blocks out over half the target attached to the top edge of the grapple fixture. The RMS wrist joint and shadow partially block a view of the black chevrons. The chromic-anodized aluminum mounting plate and the upper and lower flanges of the tray are discolored by a light tan stain.

Figure 221
Photo No.: S32-89-048
Dup. Neg. No.: L90-10501
LISAR No.: EL-1994-00135
Photo Credit: JSC
Photo Date: 1/12/90
Location: In Flight
Subject: In-Flight Survey of Tray C1

***Figure 222 (Postflight).*** The grapple tray assembly appears to be without physical damage. The dark irregular discoloration on the lower right corner of the grapple fixture mounting plate is an abrasion that existed preflight. The pinkish tint on the mounting plate is a by-product of the chromic anodizing process and is not attributed to exposure to the space environment. The stripes on the black camera target and the tip of the vertical rod on the target have changed from white to brown. The light band along the right edge of the grapple fixture mounting plate is caused by light reflecting from the tray sidewalls.

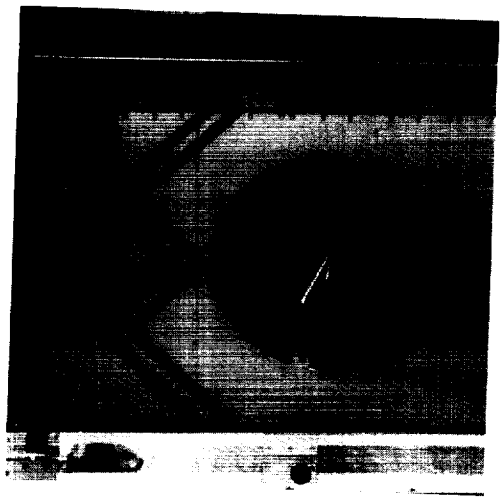

Figure 222
Photo No.: KSC-390C-609.08
Dup. Neg. No.: L92-17834
LISAR No.: EL-1994-00120
Photo Credit: KSC
Photo Date: 1/30/90
Location: KSC OPF
Subject: Postflight Survey of Tray C1

## Tray C2

Free-Flyer Biostack Experiment (AO015)

Institute for Flight Medicine, DFVLR

Trays: C2 and G2

This experiment investigated the biological effect of cosmic radiation and microgravity on biomolecules, cysts, spores, and plant seeds.

Chemical and Isotopic Measurements of Micrometeoroids by Secondary Ion Mass Spectrometry (AO187-2)

McDonnell Center for the Space Sciences

Max-Planck Institute for Nuclear Physics

Munich Technical University

Ernst-Mach Institute

Dornier System Manufacturing Company

Trays: C2, E3, and E8

The objective of this experiment was to measure the chemical and the isotopic composition of interplanetary dust particles.

Space Environment Effects (M0006)

Air Force Technical Application Center

Perkin-Elmer

Grumman Aerospace Corporation

The City College

Tray: C2

The objective of this experiment was to expose samples of mirrors, fiber optic components, semiconductors, polymer films, and seeds to the space environment for postflight analysis.

***Figure 223 (Preflight).*** Experiment AO015 consisted of eight hermetically sealed aluminum housings coated with Chemglaze II A-276 white paint in the left one-third of the tray. The canisters contained the test specimens and were mounted on an anodized aluminum baseplate. Two canisters had windows covered with Kapton H foil that provided low-radiation absorption and a light filter. Two other canisters had an anodized aluminum spherical cover with an open area sufficient to limit incoming radiation from the albedo of the Earth.

Experiment AO187-2 utilized 40 experiment capture cells installed on 2 support panels that were mounted in the center one-third of the tray. A capture cell consisted of four polished high-purity germanium plates covered with a 2.5-μm-thick Mylar foil coated with 1300 A of tantalum, which was vapor deposited on the back, and 100 A of gold-palladium, which was vapor deposited on the front.

Experiment M0006 was contained within the EECC that was located in the right one-third of the experiment tray. The canister was programmed to open in flight after the LDEF was deployed and to close approximately 9 months after opening, which was prior to the scheduled retrieval of the LDEF.

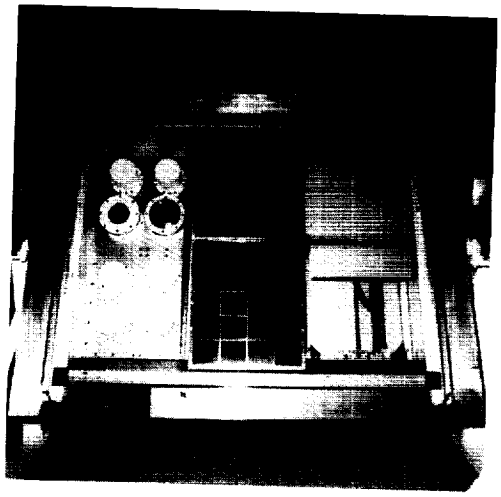

Figure 223
Photo No.: KSC-384C-144.08
Dup. Neg. No.: L84-7057
LISAR No.: EL-1994-00342
Photo Credit: KSC
Photo Date: 1/11/84
Location: KSC SAEF II
Subject: Preflight Survey of Tray C2

***Figure 224 (In Flight).*** A brown stain is on the experiment hardware within the tray. Experiment AO015 has survived the extended mission with no visible damage. The Kapton covers are intact and all hardware is securely in place. Experiment AO187-2 capture cells have been severely degraded. Few, if any, of the 40 capture cell metallized Mylar covers survived the total mission. For many cells, pieces of the failed capture cover have curled into tight conical needles and are attached to the edges of the aluminum mounting frame.

The EECC containing experiment M0006 appears to be in excellent shape.

Figure 224
Photo No.: S32-89-029
Dup. Neg. No.: L90-10498
LISAR No.: EL-1994-00133
Photo Credit: JSC
Photo Date: 1/12/90
Location: In Flight
Subject: In-Flight Survey of Tray C2

***Figure 225 (Postflight).*** Most hardware is coated with a light brown or tan stain. Only one metallized Mylar cover for experiment AO187-2 survived the total mission. For other cells, pieces of the failed metallized Mylar cover curled into a tight conical shape and adhered to the edges of the aluminum mounting frame.

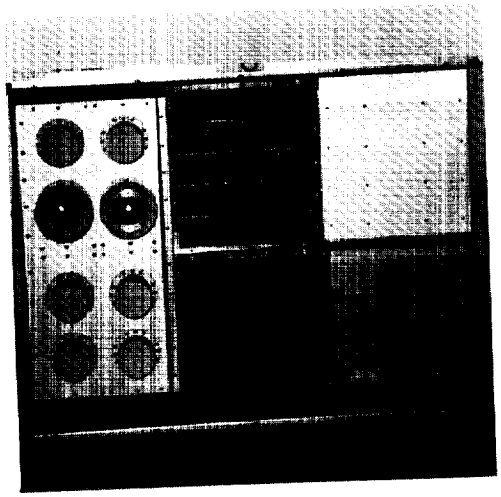

Figure 225
Photo No.: KSC-390C-609.09
Dup. Neg. No.: L92-17835
LISAR No.: EL-1994-00121
Photo Credit: KSC
Photo Date: 1/30/90
Location: KSC OPF
Subject: Postflight Survey of Tray C2

***Figure 226 (Postflight).*** This photograph is of the upper left one-sixth of the tray. The bio-stack canisters have no damage, but there is a dimple in one orange Kapton cover dome. The canisters were white prior to flight, but are now a light tan.

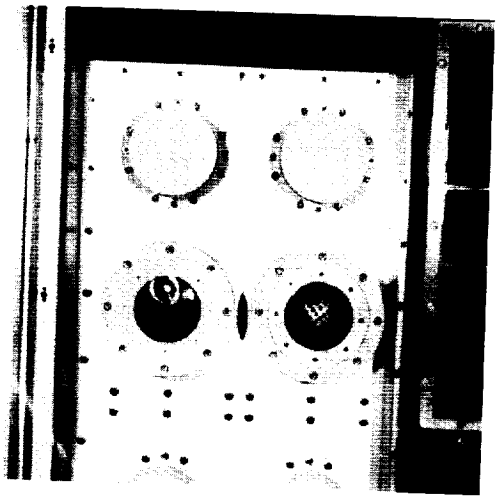

Figure 226
Photo No.: KSC-390C-1918.02
Dup. Neg. No.: L91-9048
LISAR No.: EL-1994-00427
Photo Credit: KSC
Photo Date: 3/13/90
Location: KSC SAEF II
Subject: Postflight Detail of Upper Left of Tray C2

***Figure 227 (Postflight).*** This photograph is of the upper center one-sixth of the tray. All the visible metallized Mylar capture cell covers have rolled up and are hanging loose. There are reflections of surrounding areas in the face of some capture cells.

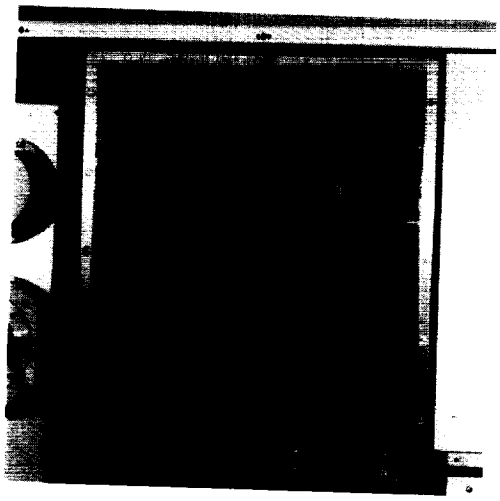

Figure 227
Photo No.: KSC-390C-1918.03
Dup. Neg. No.: L91-9049
LISAR No.: L-1994-00428
Photo Credit: KSC
Photo Date: 3/13/90
Location: KSC SAEF II
Subject: Postflight Detail of Upper Center of Tray C2

***Figure 228 (Postflight).*** This photograph is of the lower left one-sixth of the tray. The canisters appear undamaged. The biostack canisters that were white prior to flight now have a light tan discoloration.

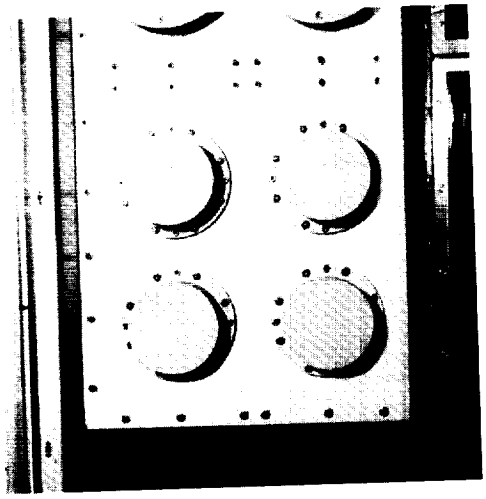

Figure 228
Photo No.: KSC-390C-1918.05
Dup. Neg. No.: L91-9051
LISAR No.: EL-1994-00429
Photo Credit: KSC
Photo Date: 3/13/90
Location: KSC SAEF II
Subject: Postflight Detail of Lower Left of Tray C2

***Figure 229 (Postflight).*** This photograph is of the lower center one-sixth of the tray. All but one of the metallized Mylar covers have rolled up and are hanging loose. There are reflections of surrounding areas in the face of some capture cells.

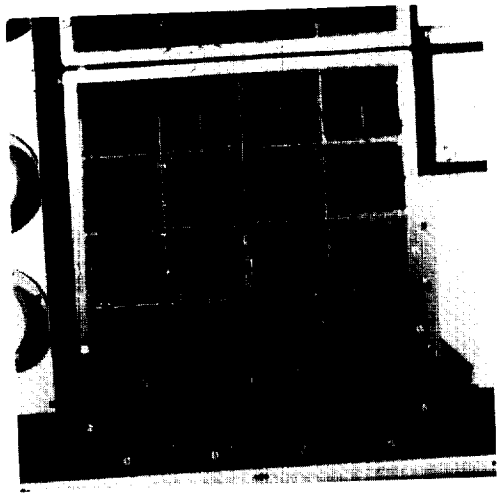

Figure 229
Photo No.: KSC-390C-1918.06
Dup. Neg. No.: L91-9052
LISAR No.: EL-1994-00430
Photo Credit: KSC
Photo Date: 3/13/90
Location: KSC SAEF II
Subject: Postflight Detail of Lower Center of Tray C2

## Tray C3

Multiple Foil Microabrasion Package (MAP) (AO023)

University of Kent

Trays: C3, C9, D12, E6, and H11

The objective of this experiment was to capture micrometeoroids and space debris particles with multiple thin aluminum and brass foil arrays, which ranged in thickness from 1.5 μm to 30 μm. This experiment looked for size, velocity, composition, and distribution of solid particles in the near-Earth environment.

Atomic Oxygen Stimulated Outgassing (AO034)

Southern University

NASA MSFC

Trays: C3 and C9

The objective of this experiment was to determine if the impingement of atomic oxygen in the near Earth environment is a major factor in producing outgassed products that are optically damaging.

Interaction of Atomic Oxygen With Solid Surfaces at Orbital Altitudes (AO114)

University of Alabama in Huntsville

NASA MSFC

Trays: C3 and C9

The objective of this experiment was to determine atomic oxygen and surface interactions in the energy range near 5 eV by exposing a wide variety of surfaces to the intense atomic flux found in flight.

Interplanetary Dust Experiment (IDE) (AO201)

Institute for Space Science and Technology

NASA LaRC

North Carolina State University

Trays: B12, C3, C9, D6, G10, and H11

The objective of this experiment was to study interplanetary dust and obtain information about particle mass and velocity.

***Figure 230 (Preflight).*** Experiment AO023 in the left one-third of the tray utilized thin-film detectors bonded to brass mesh supports. The support mesh was then bonded to die-cast aluminum frames. The die-cast aluminum frames, stacked two high, were placed over a polished aluminum stop plate and the combined assembly was bolted to an aluminum mounting plate.

Experiment AO034 in the upper center one-sixth of the tray exposed selected thermal control coatings to atomic oxygen and the synergistic effects of the space environment. Modules defined 25 individual compartments for thermal control specimens. Optical mirrors were located adjacent to the thermal control samples to assess damaging outgassing.

Experiment AO114 in the lower center one-sixth of the tray contained 64 1-in-diameter solid samples, which included thin-film metals and nonmetals.

Experiment AO201, which was located in the right one-third of the tray, exposed 80 detectors that are described in figure 211.

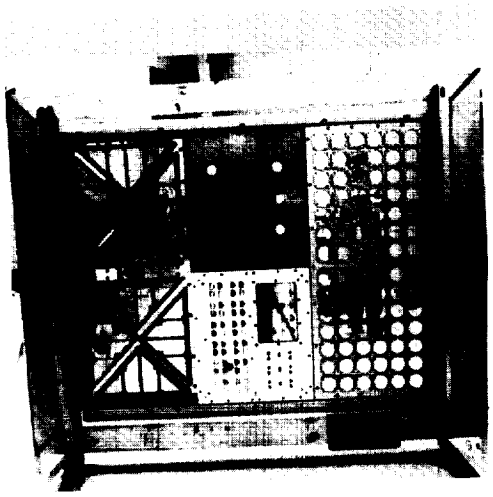

Figure 230
Photo No.: KSC-384C-15.01
Dup. Neg.: L84-7015
LISAR No.: EL-1994-00332
Photo Credit: KSC
Photo Date: 1/9/84
Location: KSC SAEF II
Subject: Preflight Survey of Tray C3

***Figure 231 (In Flight).*** There is a brown stain on the tray structure and most aluminum surfaces of experiments within the tray. Experiment AO023 appears intact. The blue tint on the detector foils and also on the polished aluminum stop plates between the detector stacks is the reflection of the sky on the metallic surfaces.

The S13G-LO white paint on experiment AO114 has turned to a light tan with darker areas near the coverplate edges and above the polished aluminum cover plate. The blue tint on the polished aluminum cover plate and some of the specimen materials is attributed to a reflection of the sky.

The hardware of experiment AO201 that is not in shadow appears to have a thin brown film or stain on the exposed surfaces. The colors in the mirrorlike surface of the detectors are a reflection of the sky and the clouds.

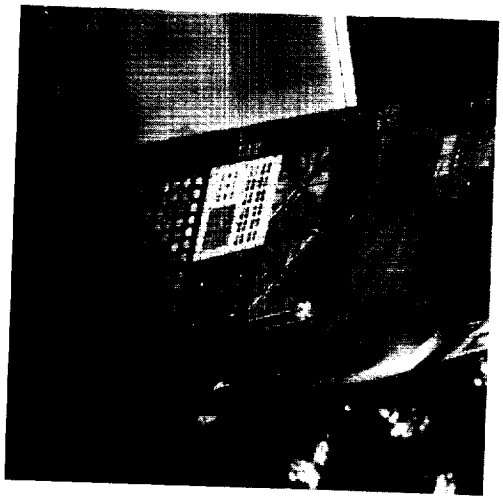

Figure 231
Photo No.: S32-77-065
Dup. Neg. No.: L90-10416
LISAR No.: EL-1994-00682
Photo Credit: JSC
Photo Date: 1/12/90
Location: In Flight
Subject: In-Flight Survey of Tray C3

***Figure 232 (Postflight).*** Experiment surfaces have a brown stain that is consistent with other areas on the trailing side of the LDEF. Most noticeable is that the coverplate of experiment AO114, which was painted with white paint (S13G-LO), is now light tan.

Experiment AO023 has no visible damage. The die-cast frame, the mesh, the detector foils, and the bond joints are intact. Reflections from the photographic light sources are visible on the surfaces of specimens located in the cavities behind the cover plate.

The colors and designs on detectors of experiment AO201 are reflections of the surrounding area.

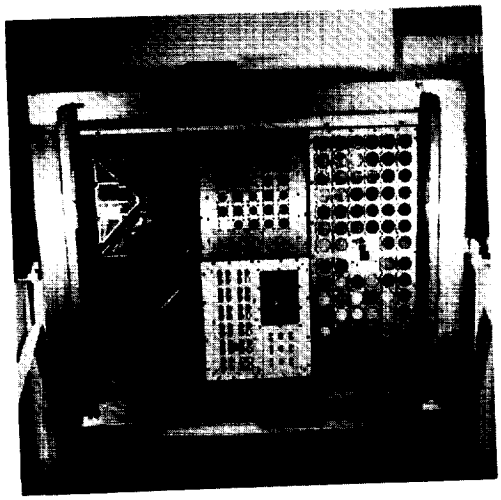

Figure 232
Photo No.: KSC-390C-1558.02
Dup. Neg. No.: L91-9090
LISAR No.: EL-1994-00213
Photo Credit: KSC
Photo Date: 3/5/90
Location: KSC SAEF II
Subject: Postflight Survey of Tray C3

***Figure 233 (Postflight).*** This photograph is of the upper left one-sixth of the tray. The hardware of experiment AO023 appears intact, but some discoloration on the mounting hardware surfaces is apparent. Considerable staining is visible along the bond line between the support mesh and die-cast frame where the adhesive may not have been completely cleaned during prelaunch preparations. Reflections in the foil surfaces are visible.

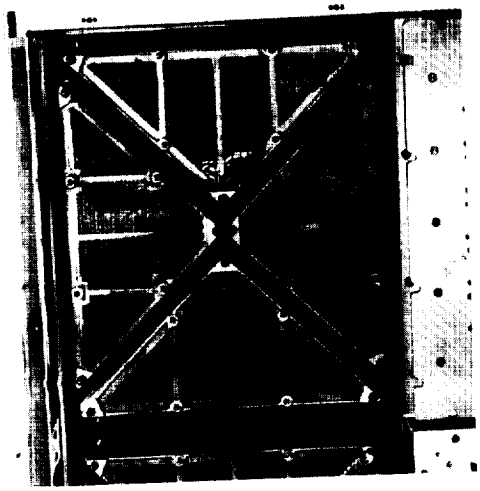

Figure 233
Photo No.: KSC-390C-1558.03
Dup. Neg. No.: L91-9091
LISAR No.: EL-1994-00339
Photo Credit: KSC
Photo Date: 3/5/90
Location: KSC SAEF II
Subject: Postflight Detail of Upper Left of Tray C3

***Figure 234 (Postflight).*** This photograph is of the upper center one-sixth of the tray. Experiment AO034 has some uniform brown discoloration on the cover plate surface. Reflections from photographic lights are visible on the sensor surfaces.

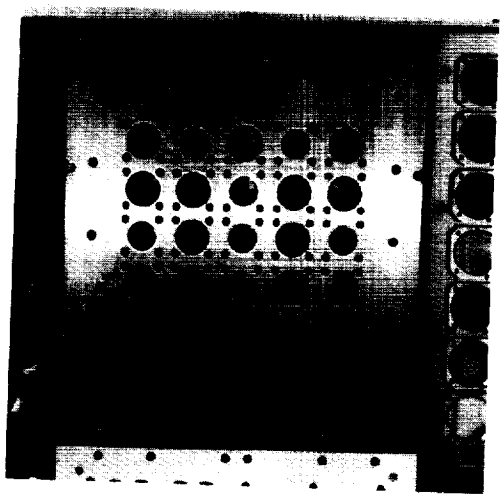

Figure 234
Photo No.: KSC-390C-1558.04
Dup. Neg. No.: L91-9092
LISAR No.: EL-1994-00340
Photo Credit: KSC
Photo Date: 3/5/90
Location: KSC SAEF II
Subject: Postflight Detail of Upper Center of Tray C3

***Figure 235 (Postflight).*** This photograph is of the upper right one-sixth of the tray. The sensors of experiment AO201 are intact. There is a brown discoloration on the detector frames and baseplate. A reflection of the room surroundings is visible in the sensor surfaces.

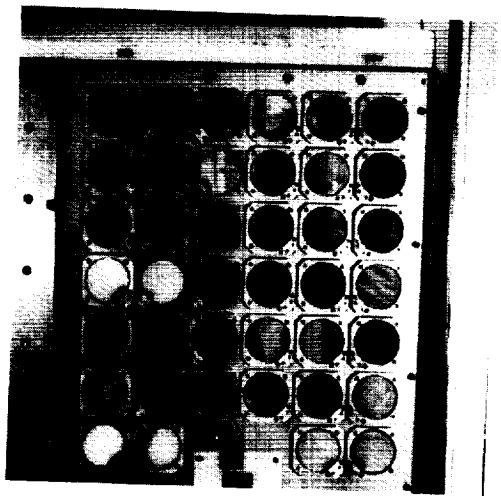

Figure 235
Photo No.: KSC-390C-1558.05
Dup. Neg. No.: L91-9093
LISAR No.: EL-1994-00351
Photo Credit: KSC
Photo Date: 3/5/90
Location: KSC SAEF II
Subject: Postflight Detail of Upper Right of Tray C3

***Figure 236 (Postflight).*** This photograph is of the lower left one-sixth of the tray. The hardware of experiment AO023 is intact, but some discoloration on the mounting hardware surfaces is apparent. Considerable staining is visible along the bond line between the support mesh and the die-cast frame where the adhesive may not have been completely cleaned during prelaunch preparations. Reflections in the foil surfaces are visible.

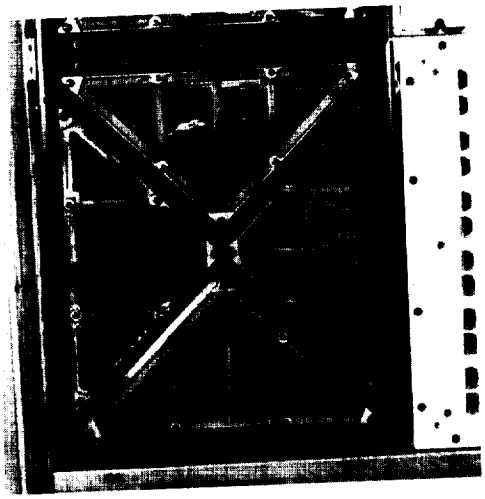

Figure 236
Photo No.: KSC-390C-1558.06
Dup. Neg. No.: L91-9094
LISAR No.: EL-1994-00352
Photo Credit: KSC
Photo Date: 3/5/90
Location: KSC SAEF II
Subject: Postflight Detail of Lower Left of Tray C3

***Figure 237 (Postflight).*** This photograph is of the lower center one-sixth of the tray. The sensors of experiment AO114 seem to be intact. The paint that was originally white on the faceplate is now a uniform light tan. The polished aluminum face plate insert in the upper right quadrant has become darker.

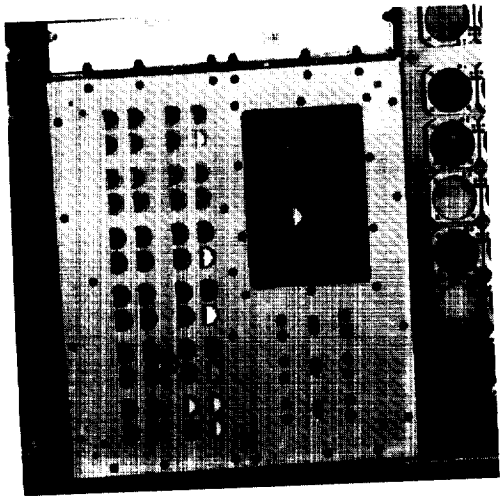

Figure 237
Photo No.: KSC-390C-1558.07
Dup. Neg. No.: L91-9095
LISAR No.: EL-1994-00364
Photo Credit: KSC
Photo Date: 3/5/90
Location: KSC SAEF II
Subject: Postflight Detail of Lower Center of Tray C3

***Figure 238 (Postflight).*** This photograph is of the lower right one-sixth of the tray. The sensors of experiment AO201 are intact. There is a brown discoloration on the detector frames and baseplate. A reflection of the nearby surroundings is visible in the sensor surfaces.

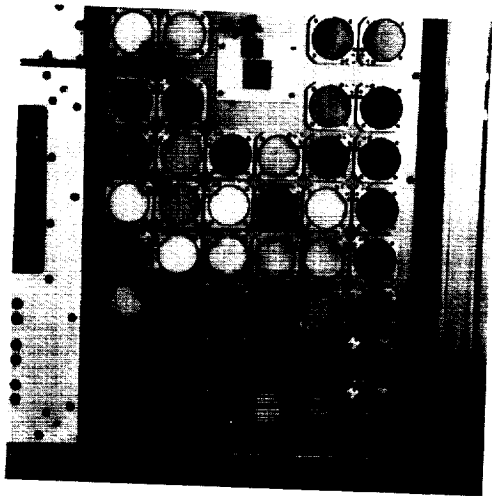

Figure 238
Photo No.: KSC-390C-1558.08
Dup. Neg. No.: L91-9096
LISAR No.: EL-1994-00365
Photo Credit: KSC
Photo Date: 3/5/90
Location: KSC SAEF II
Subject: Postflight Detail of Lower Right of Tray C3

## Tray C4

Space Debris Impact Experiment (S0001)

NASA LaRC

Trays: A5, A6, A12, B1, B2, B6, B8, B11, C4, C7, D2, D6, E1, E4, E7, E11, F1, F3, F5, F7, F10, F11, G4, G8, and H5

See section entitled "Tray A5" for a typical preflight photographic survey and experiment objective.

***Figure 239 (In Flight).*** The greenish-gray tint on the debris panels is a by-product of the chromic anodize coating process. The dark green smudge along the top right edge of the left debris panel is the result of improper cleaning after prelaunch handling. The dark band across the bottom of the panels is caused by a shadow from the tray sidewall.

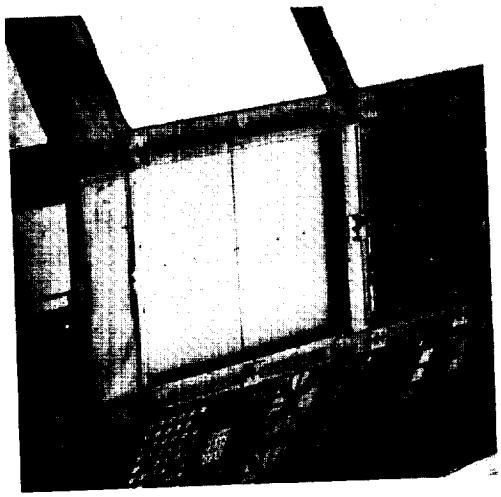

Figure 239
Photo No.: S32-77-031
Dup. Neg. No.: L90-10408
LISAR No.: EL-1994-00091
Photo Credit: JSC
Photo Date: 1/12/90
Location: In Flight
Subject: In-Flight Survey of Tray C4

***Figure 240 (Postflight).*** The greenish-gray and pink tints on the two debris panels are by-products of the chromic anodize coating process and are not attributed to contamination or exposure to the space environment. The smudges on the panels along the bottom center of the tray are the result of improper cleaning after panel installation. The light band along the sides and across the top of the panels is caused by light reflecting from the tray sidewalls.

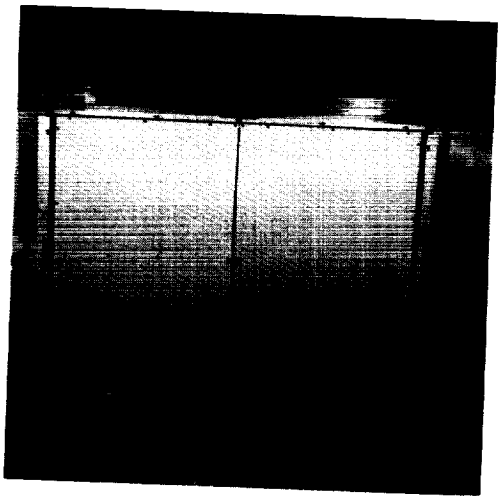

Figure 240
Photo No.: KSC-390C-832.05
Dup. Neg. No.: L90-13352
LISAR No.: EL-1994-00173
Photo Credit: KSC
Photo Date: 2/7/90
Location: KSC SAEF II
Subject: Postflight Survey of Tray C4

## Tray C5

A High-Resolution Study of Ultraheavy Cosmic Ray Nuclei (UHCRE) (AO178)

Dublin Institute for Advanced Studies ESA at ESTEC

Trays: A2, A4, A10, B5, B7, C5, C6, C8, C11, D1, D5, D7, D11, E2, E10, and F4

See section entitled "Tray D5" and figure 319 for a typical preflight photograph of experiment AO178. No in-flight photograph was taken of tray C5.

***Figure 241 (Postflight).*** The thermal cover appears to be specular with no apparent damage. The cover is less taut than in the in-flight photograph and the locations of Velcro attachment pads are less prominent. The green on the right one-third of the thermal cover are reflections from the surroundings. The scallop effect around the cover edges occurs between the attachment pads and shows the upper edge of the support frame. The ground strap is in place with no visible damage; however, it is a deeper copper color than in the prelaunch photograph.

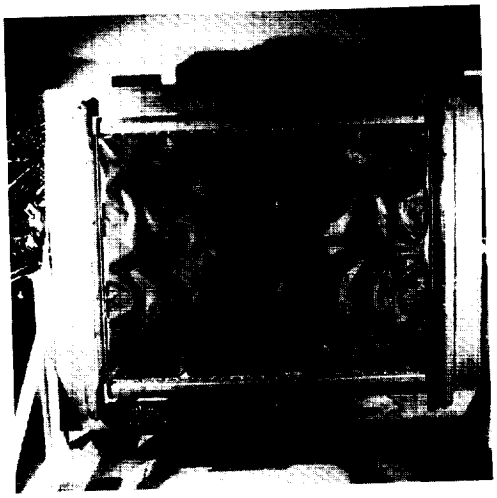

Figure 241
Photo No.: KSC-390C-1467.02
Dup. Neg. No.: L91-8928
LISAR No.: EL-1994-00205
Photo Credit: KSC
Photo Date: 2/23/90
Location: KSC SAEF II
Subject: Postflight Survey of Tray C5

## Tray C6

A High-Resolution Study of Ultraheavy Cosmic Ray Nuclei (UHCRE) (AO178)

Dublin Institute for Advanced Studies ESA at ESTEC

Trays: A2, A4, A10, B5, B7, C5, C6, C8, C11, D1, D5, D7, D11, E2, E10, and F4

See section entitled "Tray D5" and figure 319 for a typical preflight photograph of experiment AO178.

No in-flight photograph was taken for tray C6.

***Figure 242 (Postflight).*** The thermal cover appears to be specular with no apparent damage. The green on the right one-third of the thermal cover are reflections from the surroundings. The ground strap is in place with no visible damage; however, it is a deeper copper color than in the prelaunch photograph.

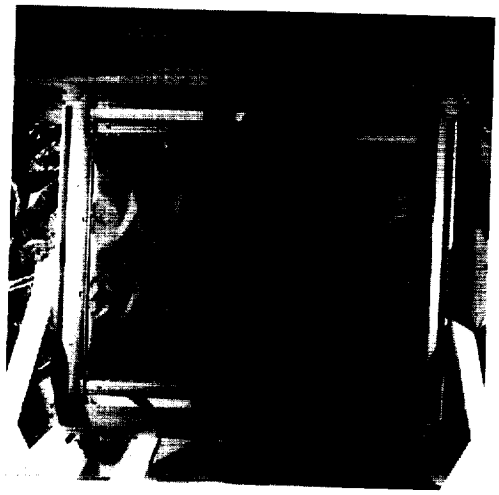

Figure 242
Photo No.: KSC-390C-1467.08
Dup. Neg. No.: L91-8905
LISAR No.: EL-1994-00206
Photo Credit: KSC
Photo Date: 2/23/90
Location: KSC SAEF II
Subject: Postflight Survey of Tray C6

## Tray C7

Space Debris Impact Experiment (S0001)

NASA LaRC

Trays: A5, A6, A12, B1, B2, B6, B8, B11, C4, C7, D2, D6, E1, E4, E7, E11, F1, F3, F5, F7, F10, F11, G4, G8, and H5

See section entitled "Tray A5" for a typical preflight photographic survey and experiment objective.

No in-flight photograph was available.

***Figure 243 (Postflight).*** The pink and greenish-gray tints on the two debris panels are by-products of the chromic anodize coating process and are not attributed to contamination or exposure to the space environment. The two white spots in the lower left quadrant of the left debris panel appear to be debris impact craters. The light band along the right side and across the bottom of the panels is caused by light reflecting from the tray sidewalls.

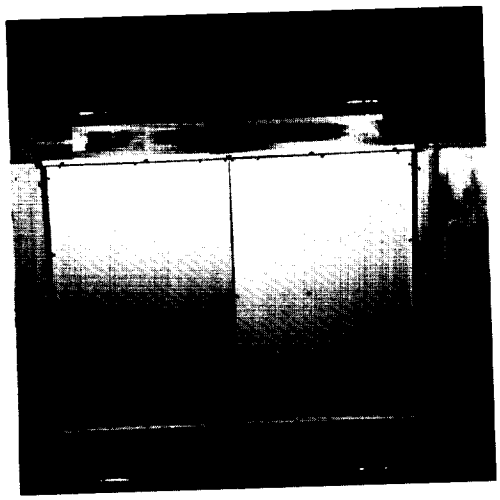

Figure 243
Photo No.: KSC-390C-1032.05
Dup. Neg. No.: L90-13427
LISAR No.: EL-1994-00032
Photo Credit: KSC
Photo Date: 2/9/90
Location: KSC SAEF II
Subject: Postflight Survey of Tray C7

## Tray C8

A High-Resolution Study of Ultraheavy Cosmic Ray Nuclei (UHCRE) (AO178)

Dublin Institute for Advanced Studies

ESA at ESTEC

Trays: A2, A4, A10, B5, B7, C5, C6, C8, C11, D1, D5, D7, D11, E2, E10, and F4

See section entitled "Tray D5" and figure 319 for a typical preflight photograph of experiment AO178.

***Figure 244 (In Flight).*** The ground strap located in the center of the lower flange is intact but with a much darker copper color than in the prelaunch photograph. The thermal cover surface appears to have changed from specular to opaque (glossy white) and to be marked with many black dots of various sizes that appear to be impacts or penetrations. Many discolorations have a black center encircled by a brown halo. The cover appears to be more taut than in the prelaunch photograph and the locations of Velcro attachment pads appear as oblong indentations in the thermal cover.

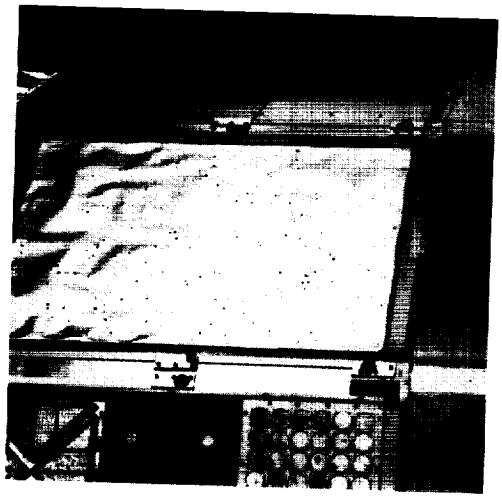

Figure 244
Photo No.: S32-76-008
Dup. Neg. No.: L90-10376
LISAR No.: EL-1994-00661
Photo Credit: JSC
Photo Date: 1/12/90
Location: In Flight
Subject: In-Flight Survey of Tray C8

***Figure 245 (Postflight).*** The thermal cover surface appears to have changed from specular to opaque (glossy white) with many black dots of various sizes that appear to be impact or penetration discolorations. Many of the discolorations appear to have a black center encircled by a brown halo and then by a white halo. Other white circular discolorations also appear on the cover surface. The darker discolorations are probably the result of craters penetrating the 5-mil Teflon film, thus allowing atomic oxygen to oxidize or erode the layer of vapor-deposited silver beneath. An item of interest is the impact crater in the lower right corner of the cover that has a spray pattern originating from the point of impact. The cover is not as taut as in the in-flight photograph and the locations of Velcro attachment pads are not as prominent. The ground strap is in place with no visible damage; however, it is a deeper copper color.

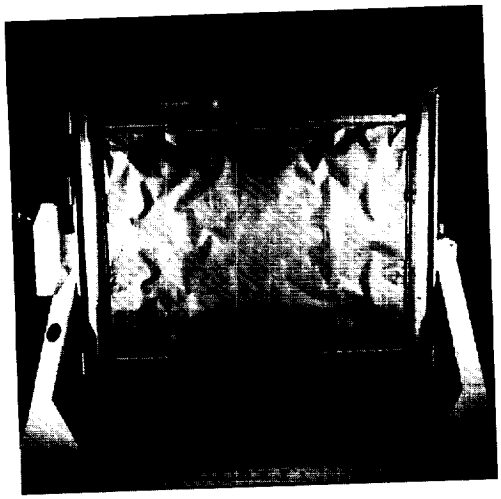

Figure 245
Photo No.: KSC-390C-1543.09
Dup. Neg. No.: L91-8886
LISAR No.: EL-1994-00212
Photo Credit: KSC
Photo Date: 3/2/90
Location: KSC SAEF II
Subject: Postflight Survey of Tray C8

***Figure 246 (Postflight).*** This photograph is of the upper left one-sixth of the tray. The thermal cover appears opaque with numerous discolored impacts or penetrations. The thermal cover Velcro attachment pads are evident.

Figure 246
Photo No.: KSC-390C-1543.10
Dup. Neg.: L91-8887
LISAR No.: EL-1994-00154
Photo Credit: KSC
Photo Date: 3/2/90
Location: KSC SAEF II
Subject: Postflight Detail of Upper Left of Tray C8

***Figure 247 (Postflight).*** This photograph is of the upper center one-sixth of the tray. The thermal cover appears opaque with numerous discolored impacts or penetrations. The thermal cover Velcro attachment pads are evident.

Figure 247
Photo No.: KSC-390C-1543.11
Dup. Neg. No.: L91-8888
LISAR No.: EL-1994-00155
Photo Credit: KSC
Photo Date: 3/2/90
Location: KSC SAEF II
Subject: Postflight Detail of Upper Center of Tray C8

***Figure 248 (Postflight).*** This photograph is of the upper right one-sixth of the tray. The thermal cover appears opaque with numerous discolored impacts or penetrations. The thermal cover Velcro attachment pads are evident.

Figure 248
Photo No.: KSC-390C-1543.12
Dup. Neg. No.: L91-8889
LISAR No.: EL-1994-00156
Photo Credit: KSC
Photo Date: 3/2/90
Location: KSC SAEF II
Subject: Postflight Detail of Upper Right of Tray C8

***Figure 249 (Postflight).*** This photograph is of the lower right one-sixth of the tray. The thermal cover appears opaque with numerous discolored impacts or penetrations. The thermal cover Velcro attachment pads are evident.

Figure 249
Photo No.: KSC-390C-1544.03
Dup. Neg. No.:L91-8892
LISAR No.: EL-1994-00259
Photo Credit: KSC
Photo Date: 3/2/90
Location: KSC SAEF II
Subject: Postflight Detail of Lower Right of Tray C8

***Figure 250 (Postflight).*** This photograph is of the lower center one-sixth of the tray. The thermal cover appears opaque with numerous discolored impacts or penetrations. The thermal cover Velcro attachment pads are evident.

Figure 250
Photo No.: KSC-390C-1544.04
Dup. Neg. No.: L91-8893
LISAR No.: EL-1994-00260
Photo Credit: KSC
Photo Date: 3/2/90
Location: KSC SAEF II
Subject: Postflight Detail of Lower Center of Tray C8

***Figure 251 (Postflight).*** This photograph is of the lower left one-sixth of the tray. The thermal cover appears opaque with numerous discolored impacts or penetrations. The thermal cover Velcro attachment pads are evident.

Figure 251
Photo No.: KSC-390C-1544.05
Dup. Neg. No.: L91-8894
LISAR No.: EL-1994-00274
Photo Credit: KSC
Photo Date: 3/2/90
Location: KSC SAEF II
Subject: Postflight Detail of Lower Left of Tray C8

***Figure 252 (Postflight).*** This close-up is of an impact or penetration in the lower right of the tray. A pronounced spray pattern extends away from the point of impact.

Figure 252
Photo No.: KSC-390C-1544.06
Dup. Neg. No.: L91-8895
LISAR No.: EL-1994-00275
Photo Credit: KSC
Photo Date: 3/2/90
Location: KSC SAEF II
Subject: Postflight Detail of Impact Point in Tray C8

## Tray C9

Multiple Foil Microabrasion Package (MAP) (AO023)

University of Kent

Trays: C3, C9, D12, E6, and H11

The objective of this experiment was to capture micrometeoroids and space debris particles with multiple thin aluminum and brass foil arrays, which ranged in thickness from 1.5 μm to 30 μm. This experiment looked for size, velocity, composition, and distribution of solid particles in the near-Earth environment.

Atomic Oxygen Stimulated Outgassing (AO034)

Southern University

NASA MSFC

Trays: C3 and C9

The objective of this experiment was to determine if the impingement of atomic oxygen in the near-Earth environment is a major factor in producing outgassed products that are optically damaging.

Interaction of Atomic Oxygen with Solid Surfaces at Orbital Altitudes (AO114)

University of Alabama in Huntsville

NASA MSFC

Trays: C3 and C9

The objective of this experiment was to determine atomic oxygen and surface interactions in the energy range near 5 eV by exposing a wide variety of surfaces to the intense atomic flux found in flight.

Interplanetary Dust Experiment (IDE) (AO201)

Institute for Space Science and Technology

NASA LaRC

North Carolina State University

Trays: B12, C3, C9, D6, G10, and H11

The objective of this experiment was to study interplanetary dust and obtain information about particle mass and velocity.

***Figure 253 (Preflight).*** The prelaunch photograph shows the location of four experiments integrated into a 3-in-deep tray. Experiment AO023 is located in the left one-third, experiment AO034 in the upper center, experiment AO114 in the lower center, and experiment AO201 in the right one-third of the tray. Experiment AO201 is described in figure 211 and the other experiments are described in figure 230.

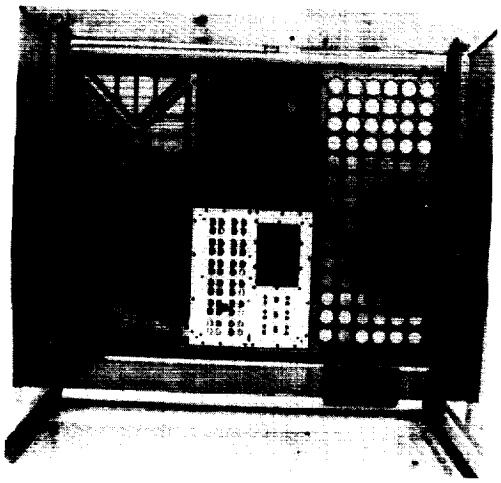

Figure 253
Photo No.: KSC-384C-14.03
Dup. Neg.: L84-7005
LISAR No.: EL-1994-00330
Photo Credit: KSC
Photo Date: 1/9/84
Location: KSC SAEF II
Subject: Preflight Survey of Tray C9

***Figure 254 (In Flight).*** The tray appears to be unchanged from the preflight condition except for a little discoloration around some fasteners and on the mounting plates. Reflections of the surroundings appear to exist on some sensor surfaces. All experiment hardware appears intact. The color of the center coverplates was influenced by lighting conditions.

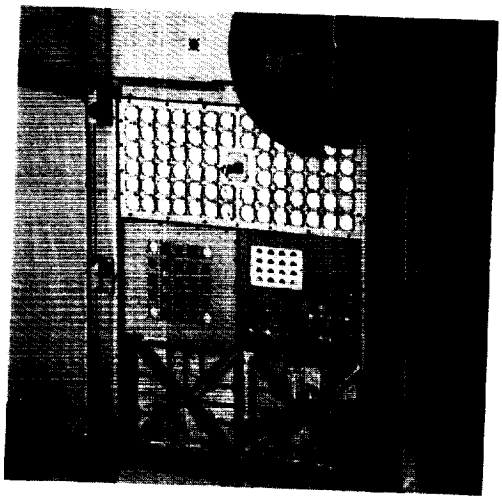

Figure 254
Photo No.: S32-78-100
Dup. Neg. No.: L90-10451
LISAR No.: EL-1994-00022
Photo Credit: JSC
Photo Date: 1/12/90
Location: In Flight
Subject: In-Flight Survey of Tray C9

***Figure 255 (Postflight).*** The tray corner clamp blocks are unanodized aluminum, which accounts for the difference in color between the corner clamp blocks and the center clamp blocks. All experiments are intact. Reflections of the surroundings are visible in the sensor surfaces.

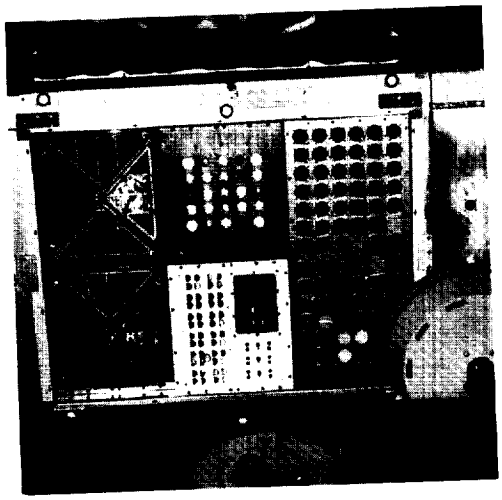

Figure 255
Photo No.: KSC-390C-1030.09
Dup. Neg. No.: L90-13407
LISAR No.: EL-1994-00143
Photo Credit: KSC
Photo Date: 2/9/90
Location: KSC SAEF II
Subject: Postflight Survey of Tray C9

***Figure 256 (Postflight).*** This photograph is of the lower left one-sixth of the tray. The mesh support, the detector foils, and the bond joints show no sign of physical failure. There are some darker contamination stains in areas on the die-cast aluminum frames where adhesive residue remained after preflight cleaning.

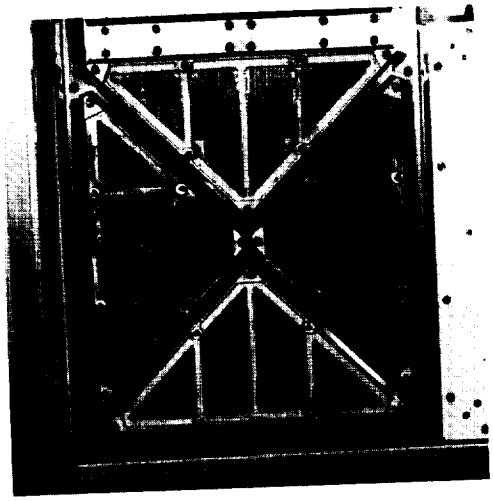

Figure 256
Photo No.: KSC-390C-1538.02
Dup. Neg. No.: L91-8840
LISAR No.: EL-1994-00692
Photo Credit: KSC
Photo Date: 3/2/90
Location: KSC SAEF II
Subject: Postflight Detail of Lower Left of Tray C9

***Figure 257 (Postflight).*** This photograph is of the lower one-sixth of the tray. Experiment AO114 shows a little change in the color of the white paint. A very faint tan tint exists around the outside edges of the cover plate and the outside ring of fasteners. The material specimens remain intact in their mountings and seem to have survived well the exposure to the space environment. The polished aluminum cover plate has darkened and seems to have a duller finish than in the preflight photograph.

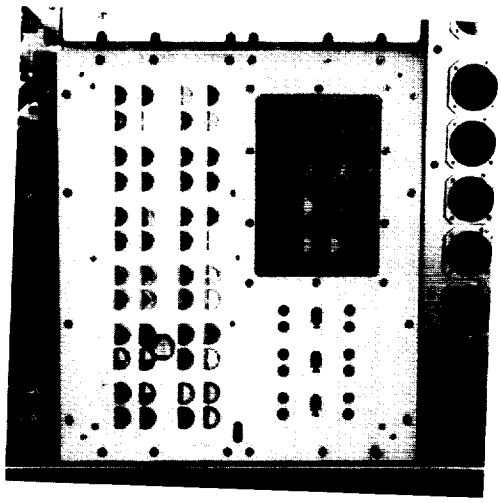

Figure 257
Photo No.: KSC-390C-1538.03
Dup. Neg. No.: L91-8841
LISAR No.: EL-1994-00693
Photo Credit: KSC
Photo Date: 3/2/90
Location: KSC SAEF II
Subject: Postflight Detail of Lower Part of Tray C9

***Figure 258 (Postflight).*** This photograph is of the lower right one-sixth of the tray. Close inspection of the photograph reveals several locations where impacts on detector surfaces are visible. A faint gold or tan stain is visible around several fasteners and in a rectangular configuration near the center along the bottom edge of the detector mounting plate. Stains are also visible near the top right edge of the solar sensor, on the mounting plate, and around the extreme edges of the solar sensor baseplate. The colors and designs on the detectors are reflections of the surrounding area.

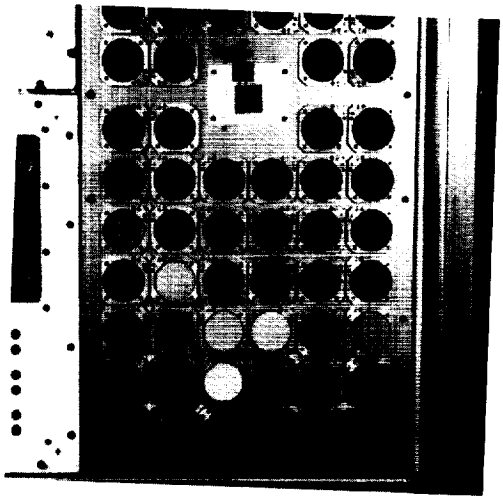

Figure 258
Photo No.: KSC-390C-1538.04
Dup. Neg. No.: L91-8842
LISAR No.: EL-1994-00694
Photo Credit: KSC
Photo Date: 3/2/90
Location: KSC SAEF II
Subject: Postflight Detail of Lower Right of Tray C9

***Figure 259 (Postflight).*** This photograph is of the upper left one-sixth of the tray. The sensor foils are intact, but some areas of the mounting frames appear discolored.

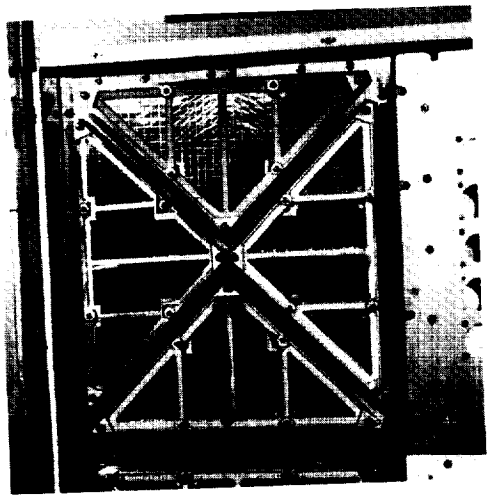

Figure 259
Photo No.: KSC-390C-1538.10
Dup. Neg. No.: L91-8848
LISAR No.: EL-1994-00648
Photo Credit: KSC
Photo Date: 3/2/90
Location: KSC SAEF II
Subject: Postflight Detail of Upper Left of Tray C9

***Figure 260 (Postflight).*** This close-up is of a portion of the upper center one-sixth of the tray. The test specimens appear intact. Some shadows appear on some of the recessed test specimens.

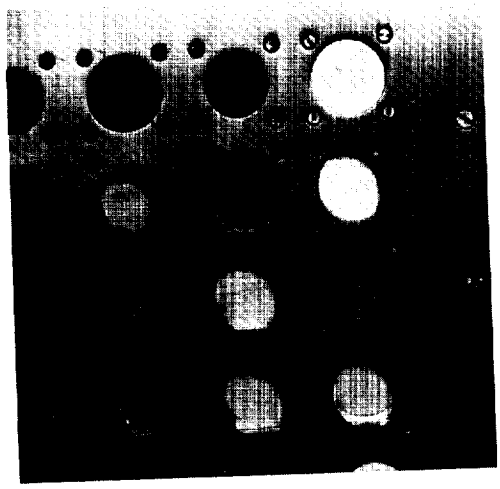

Figure 260
Photo No.: KSC-390C-1540.08
Dup. Neg. No.: L91-8858
LISAR No.: EL-1994-00152
Photo Credit: KSC
Photo Date: 3/2/90
Location: KSC SAEF II
Subject: Postflight Detail of Upper Center of Tray C9

***Figure 261 (Postflight).*** This close-up is of the upper right one-sixth of the tray. The impact sensors are intact. The different colors are reflections of the surrounding area. Evidence of space debris impacts are visible on some of the lighter colored sensors. Some light discoloration is visible around the baseplate fasteners.

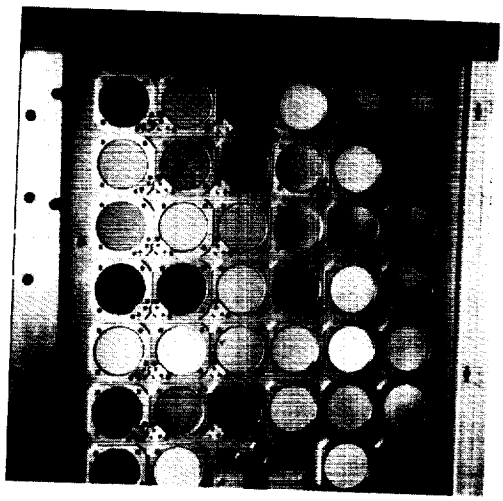

Figure 261
Photo No.: KSC-390C-1542.02
Dup. Neg. No.: L91-10128
LISAR No.: EL-1994-00153
Photo Credit: KSC
Photo Date: 3/2/90
Location: KSC SAEF II
Subject: Postflight Detail of Upper Right of Tray C9

## Tray C10

This tray contained the grapple that was used by the RMS to activate the experiment initiate system.

***Figure 262 (Preflight).*** The tray assembly consisted of a modified 6-in-deep peripheral experiment tray, a chromic-anodized aluminum mounting plate with chamfered corners, an initiate switch assembly, an initiate system status indicator assembly, nonmagnetic stainless steel fasteners, and a modified mechanical grapple fixture that was provided by JSC with a camera target attached. The camera target, which was black with white markings, was attached to the right edge of the grapple fixture and assisted the operator in positioning the RMS end effecter. The opening in the upper left corner of the mounting plate provided access to the initiate system activation connectors and was covered by an aluminum plate prior to installing the LDEF in the cargo bay of the orbiter. The black square in the right center of the mounting plate adjacent to the camera target, is the initiate system status indicator assembly. Scratch marks from preassembly activities are visible on the lower right corner and on the upper left corner slightly below the access opening of the grapple fixture mounting plate.

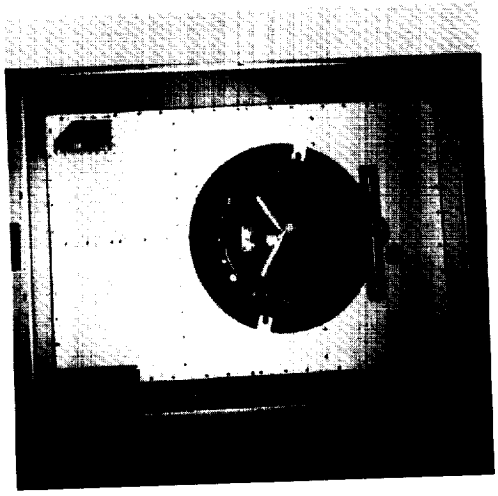

Figure 262
Photo No.: KSC-383C-4418.06
Dup. Neg. No.: L84-7314
LISAR No.: EL-1994-00317
Photo Credit: KSC
Photo Date: 12/8/83
Location: KSC SAEF II
Subject: Preflight Survey of Tray C10

***Figure 263 (In Flight).*** The grapple tray assembly appears to be without physical damage. The color of the tray and surrounding areas of the LDEF have a somewhat unrealistic pink or orange cast. The dark gray circular discolorations on the outer section of the grapple fixture appear to be the locations of impact craters where the surrounding surface coating has been disturbed.

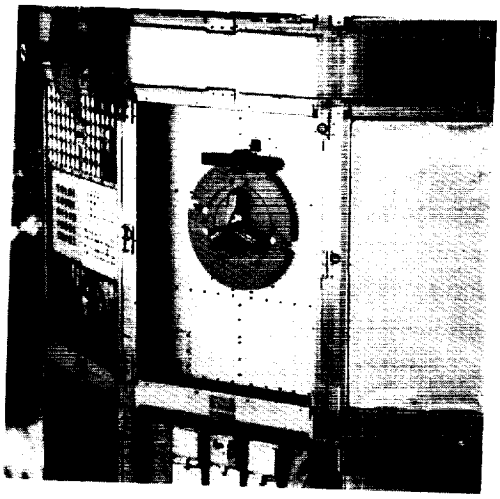

Figure 263
Photo No.: S32-78-073
Dup. Neg. No.: L90-10443
LISAR No.: EL-1994-00016
Photo Credit: JSC
Photo Date: 1/12/90
Location: In Flight
Subject: In-Flight Survey of Tray C10

***Figure 264 (Postflight).*** The grapple tray assembly is without physical damage. The chromic anodized aluminum mounting plate is in prelaunch condition with only a very light tan discoloration. The aluminum cover plate located in the lower right corner of the tray has a number of irregular darker discolorations around the outer edges that appear to be fingerprints. The dark gray circular discolorations on the outer section of the grapple fixture are impact craters where the surrounding surface coating has been disturbed.

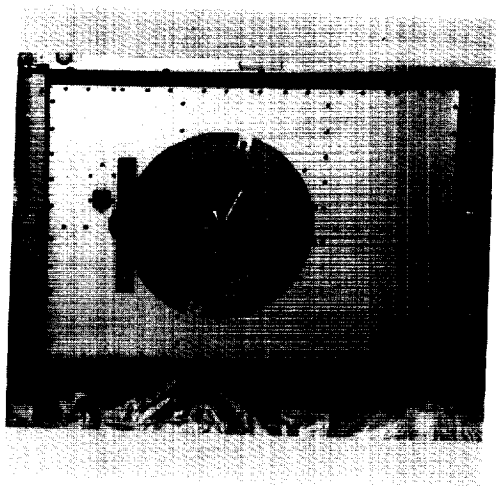

Figure 264
Photo No.: KSC-390C-612.03
Dup. Neg. No.: L92-17794
LISAR No.: EL-1994-00161
Photo Credit: KSC
Photo Date: 1/30/90
Location: KSC OPF
Subject: Postflight Survey of Tray C10

***Figure 265 (Postflight).*** This close-up is of one of the impact craters on the grapple fixture. Other small impact areas are visible.

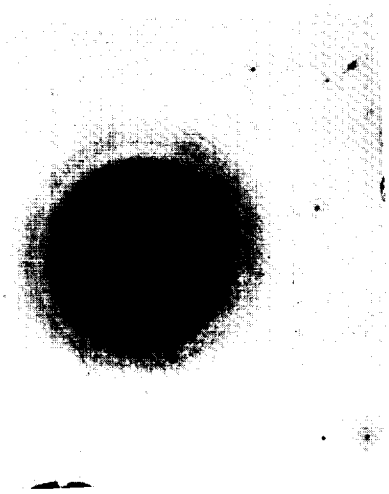

Figure 265
Photo No.: KSC-390C-3388.02
Dup. Neg. No.: L91-8814
LISAR No.: EL-1994-00610
Photo Credit: KSC
Photo Date: 4/18/90
Location: KSC SAEF II
Subject: Postflight Detail of Tray C10

## Tray C11

A High-Resolution Study of Ultraheavy Cosmic Ray Nuclei (UHCRE) (AO178)

Dublin Institute for Advanced Studies ESA at ESTEC

Trays: A2, A4, A10, B5, B7, C5, C6, C8, C11, D1, D5, D7, D11, E2, E10, and F4

See section entitled "Tray D5" and figure 319 for a typical preflight photograph of experiment AO178.

***Figure 266 (In Flight).*** The thermal cover surface appears to have changed from specular to opaque. There are indications of a number of impacts on or penetrations of the thermal cover. The cover is more taut than in the prelaunch photograph and the locations of Velcro attachment pads are apparent. The ground strap is in place with no visible damage, but it is a darker color.

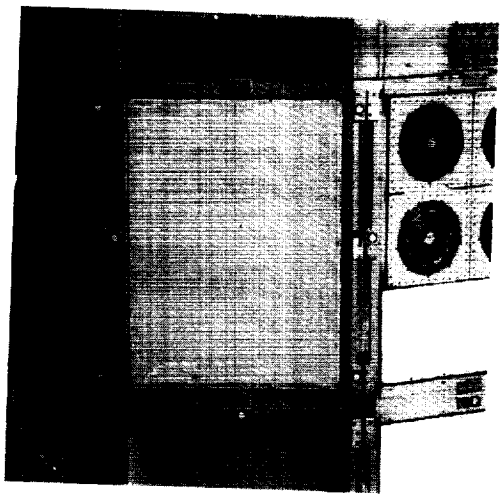

Figure 266
Photo No.: S32-78-042
Dup. Neg. No.: L90-10434
LISAR No.: EL-1994-00010
Photo Credit: JSC
Photo Date: 1/12/90
Location: In Flight
Subject: In-Flight Survey of Tray C11

***Figure 267 (Postflight).*** The thermal cover surface appears to have changed from specular to opaque with many black dots of various sizes that indicate impacts on or penetrations of the thermal cover. Photographic light reflections wash out many of the details. The cover is not as taut as in the in-flight photograph and locations of Velcro attachment pads are not as prominent. The ground strap is in place with no visible damage, but it is a deeper copper color.

Figure 267
Photo No.: KSC-390C-2109.09
Dup. Neg. No.: L91-9372
LISAR No.: EL-1994-00299
Photo Credit: KSC
Photo Date: 3/20/90
Location: KSC SAEF II
Subject: Postflight Survey of Tray C11

***Figure 268 (Postflight).*** This photograph is of the upper left one-sixth of the tray. The thermal cover appears opaque rather than specular as it was in preflight photographs. The numerous discolorations indicate impacts on or penetrations of the thermal cover. The Velcro thermal cover attachment pads are evident.

Figure 268
Photo No.: KSC-390C-2109.10
Dup. Neg. No.: L91-9373
LISAR No.: EL-1994-00484
Photo Credit: KSC
Photo Date: 3/20/90
Location: KSC SAEF II
Subject: Postflight Detail of Upper Left of Tray C11

***Figure 269 (Postflight).*** This photograph is of the upper center one-sixth of the tray. The thermal cover appears opaque rather than specular as it was in preflight photographs. The numerous discolorations indicate impacts on or penetrations of the thermal cover. The Velcro thermal cover attachment pads are evident.

Figure 269
Photo No.: KSC-390C-2109.11
Dup. Neg. No.: L91-9374
LISAR No.: EL-1994-00485
Photo Credit: KSC
Photo Date: 3/20/90
Location: KSC SAEF II
Subject: Postflight Detail of Upper Center of Tray C11

***Figure 270 (Postflight).*** This photograph is of the upper right one-sixth of the tray. The white area at the upper edge is a result of darkroom film splicing. The thermal cover appears opaque rather than specular as it was in preflight photographs. The numerous discolorations indicate impacts on or penetrations of the thermal cover. The Velcro thermal cover attachment pads are evident.

Figure 270
Photo No.: KSC-390C-2109.12
Dup. Neg. No.: L91-9375
LISAR No.: EL-1994-00486
Photo Credit: KSC
Photo Date: 3/20/90
Location: KSC SAEF II
Subject: Postflight Detail of Upper Right of Tray C11

***Figure 271 (Postflight).*** This photograph is of the lower left one-sixth of the tray. The thermal cover appears opaque rather than specular as it was in preflight photographs. The numerous discolorations indicate impacts on or penetrations of the thermal cover. The Velcro thermal cover attachment pads are evident.

Figure 271
Photo No.: KSC-390C-2111.05
Dup. Neg. No.: L92-17087
LISAR No.: EL-1994-00487
Photo Credit: KSC
Photo Date: 3/20/90
Location: KSC SAEF II
Subject: Postflight Detail of Lower Left of Tray C11

***Figure 272 (Postflight).*** This photograph is of the lower center one-sixth of the tray. The thermal cover appears opaque rather than specular as it was in preflight photographs. The numerous discolorations indicate impacts on or penetrations of the thermal cover. The Velcro thermal cover attachment pads are evident.

Figure 272
Photo No.: KSC 390C-2111.06
Dup. Neg. No.: L92-17088
LISAR No.: EL-1994-00488
Photo Credit: KSC
Photo Date: 3/20/90
Location: KSC SAEF II
Subject: Postflight Detail of Lower Center of Tray C11

***Figure 273 (Postflight).*** This photograph is of the lower right one-sixth of the tray. The thermal cover appears opaque rather than specular as it was in preflight photographs. The numerous discolorations indicate impacts on or penetrations of the thermal cover. The Velcro thermal cover attachment pads are evident.

Figure 273
Photo No.: KSC-390C-2111.07
Dup. Neg. No.: L92-17089
LISAR No.: EL-1994-00489
Photo Credit: KSC
Photo Date: 3/20/90
Location: KSC SAEF II
Subject: Postflight Detail of Lower Right of Tray C11

***Figure 274 (Postflight).*** This close-up is of two impacts or penetrations with overlapping discolored areas on tray C11.

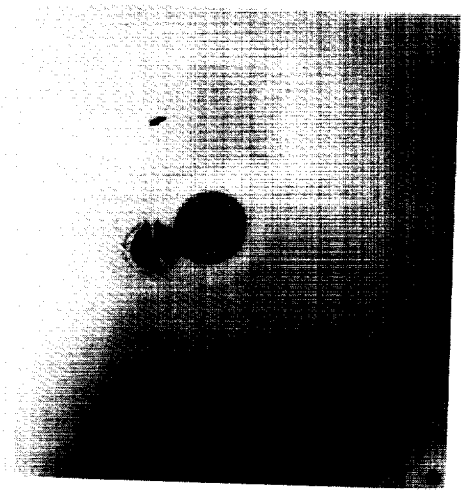

Figure 274
Photo No.: KSC-390C-2112.03
Dup. Neg. No.: L91-10151
LISAR No.: EL-1994-00490
Photo Credit: KSC
Photo Date: 3/20/90
Location: KSC SAEF II
Subject: Postflight Detail of Overlapping Impacts or Penetrations on Tray C11

## Tray C12

Fiber Optic Data Transmission Experiment (S0109)

Jet Propulsion Laboratory

Tray: C12

The objective of this experiment was to test fiber optic components in the space environment to determine their ability to operate over long periods of time without degradation of performance.

***Figure 275 (Preflight).*** The experiment included four fiber optic cables (two black, one blue, and one bright orange). Each cable was configured into a planar, helix coil. The coils were attached to the thermally isolated mounting plates with black anodized aluminum clips cushioned with silicone-rubber spacers. The four mounting plates were coated with off-white thermal control paint and the exposed surface of the cover plate was coated with Chemglaze II A-276 white paint to meet thermal control requirements. Six additional coils of fiber optic cable samples, secured with nylon cable ties, were in the bottom of the tray (four were below the mounting plates and two were below the cover plate). Each sample terminated in connectors that were mounted in brackets in the tray bottom or on the back of the thermally isolated mounting plates.

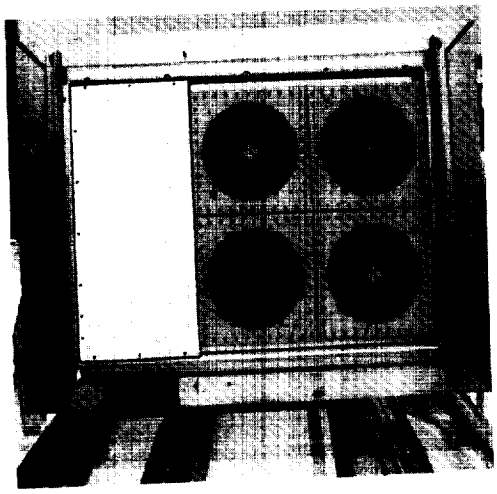

Figure 275
Photo No.: KSC-384C-300.01
Dup. Neg. No.: L89-4395
LISAR No.: EL-1994-00025
Photo Credit: KSC
Photo Date: 1/20/84
Location: KSC SAEF II
Subject: Preflight Survey of Tray C12

***Figure 276 (In Flight).*** The experiment appears to be without physical damage. The colors of two of the four exposed coils of the fiber optic cables have changed significantly. The cable located in the upper right corner, originally a bright orange, appears to be dark brown and the cable in the lower left has changed from a light blue to a blue gray. Two brown circular discolorations have appeared. One discoloration is on the lower edge of the mounting plate in the upper left and one is on the upper edge of the mounting plate in the lower right. Dark brown irregular-shaped discolorations are visible along the lower edge and on each of the vertical edges of the cover plate.

Figure 276
Photo No.:S32-89-048
Dup. Neg. No.: L90-10501
LISAR No.: EL-1994-00135
Photo Credit: JSC
Photo Date: 1/12/90
Location: In Flight
Subject: In-Flight Survey of Tray C12

***Figure 277 (Postflight).*** The colors of two coils of the externally mounted fiber optic cables have changed significantly from preflight. Four dark brown areas of discoloration are visible around the openings to the tray interior; these openings are located in the vertical seam between the mounting plates. Dark brown irregular discolorations are also visible along the vertical and upper edges of the cover plate. An irregular vertical stain (not observed in the in-flight photograph) on the upper right corner of the cover plate is now visible.

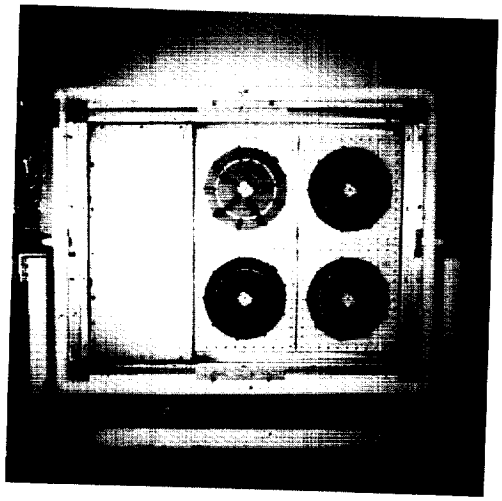

Figure 277
Photo No.: KSC-390C-2204.02
Dup. Neg. No.: L91-9317
LISAR No.: EL-1994-00300
Photo Credit: KSC
Photo Date: 3/22/90
Location: KSC SAEF II
Subject: Postflight Survey of Tray C12

***Figure 278 (Postflight).*** This photograph is of the upper left one-sixth of the tray. The cover without cable has extensive brown contamination along the left and upper edges and around the fasteners. There is a postretrieval liquid run on the upper right corner area of the cover. The existence of a liquid after almost 6 years in space was a surprise. There is also a flow pattern extending from the top edge near the left corner.

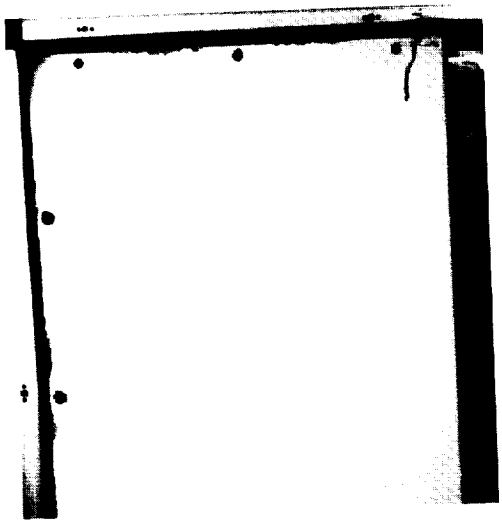

Figure 278
Photo No.: KSC-390C-2204.03
Dup. Neg. No.: L91-9318
LISAR No.: EL-1994-00616
Photo Credit: KSC
Photo Date: 3/22/90
Location: KSC SAEF II
Subject: Postflight Detail of Upper Left of Tray C12

***Figure 279 (Postflight).*** This photograph is of the upper center one-sixth of the tray. The cable has changed from a light blue to a blue gray. The color of the silicone-rubber spacers under the coil attachment clips have changed from clear to brown and have discolored the fiber coils in areas adjacent to the spacers. A flow pattern of discoloration appears to extend downward from fasteners used to secure the four mounting plates.

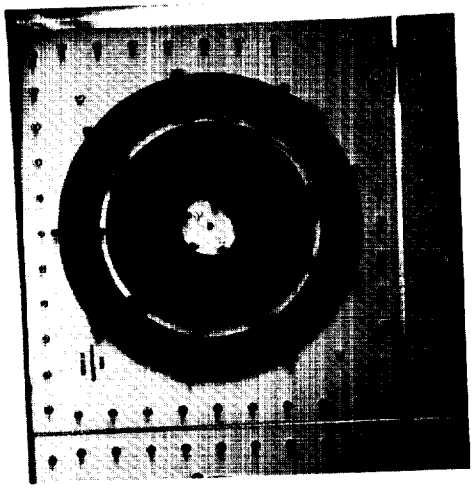

Figure 279
Photo No.: KSC-390C-2204.04
Dup. Neg. No.: L91-9319
LISAR No.: EL-1994-00526
Photo Credit: KSC
Photo Date: 3/22/90
Location: KSC SAEF II
Subject: Postflight Detail of Upper Center of Tray C12

***Figure 280 (Postflight).*** This photograph is of the upper right one-sixth of the tray. The silicone-rubber spacers under the coil attachment clips have changed from clear to brown and have discolored the fiber coils in areas adjacent to the spacers.

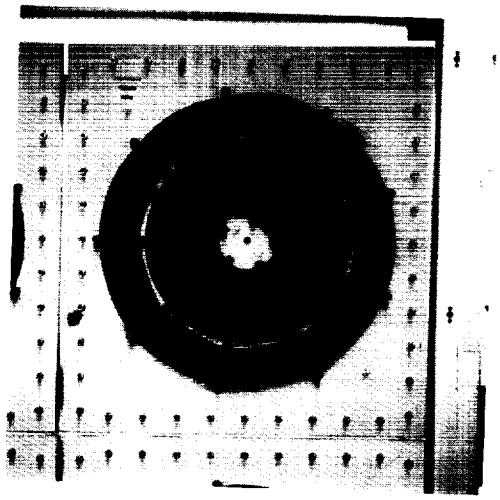

Figure 280
Photo No.: KSC-390C-2204.05
Dup. Neg. No.: L91-9320
LISAR No.: EL-1994-00527
Photo Credit: KSC
Photo Date: 3/22/90
Location: KSC SAEF II
Subject: Postflight Detail of Upper Right of Tray C12

***Figure 281 (Postflight).*** This photograph is of the lower left one-sixth of the tray. The cover without cable has extensive brown contamination along the left edge. There is also a flow pattern extending up from the bottom edge.

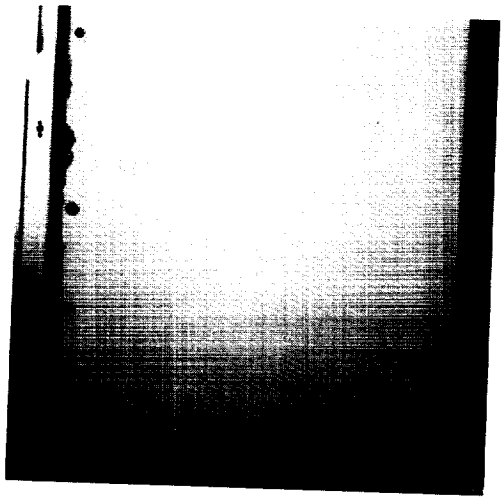

Figure 281
Photo No.: KSC-390C-2204.06
Dup. Neg. No.: L91-9321
LISAR No.: EL-1994-00619
Photo Credit: KSC
Photo Date: 3/22/90
Location: KSC SAEF II
Subject: Postflight Detail of Lower Left of Tray C12

***Figure 282 (Postflight).*** This photograph is of the lower center one-sixth of the tray. The silicone-rubber spacers under the coil attachment clips have changed from clear to brown and have discolored the fiber coils in areas adjacent to the spacers. A flow pattern of discoloration appears to extend downward from fasteners used to secure the four mounting plates.

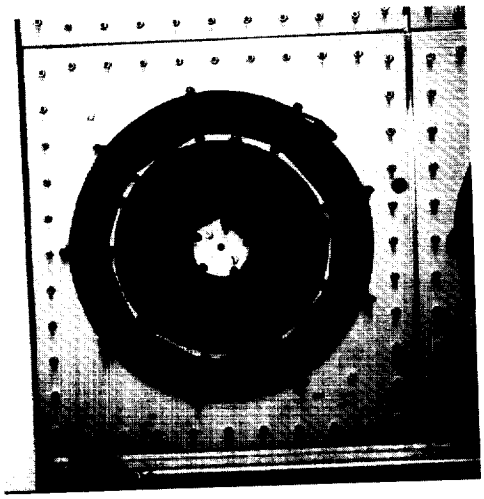

Figure 282
Photo No.: KSC-390C-2204.07
Dup. Neg. No.: L91-9322
LISAR No.: EL-1994-00528
Photo Credit: KSC
Photo Date: 3/22/90
Location: KSC SAEF II
Subject: Postflight Detail of Lower Center of Tray C12

***Figure 283 (Postflight).*** This photograph is of the lower right one-sixth of the tray. The cable, originally a bright orange, is dark brown. The silicone-rubber spacers under the coil attachment clips have changed from clear to brown and have discolored the fiber coils in areas adjacent to the spacers. A flow pattern of discoloration appears to extend downward from fasteners used to secure the four mounting plates.

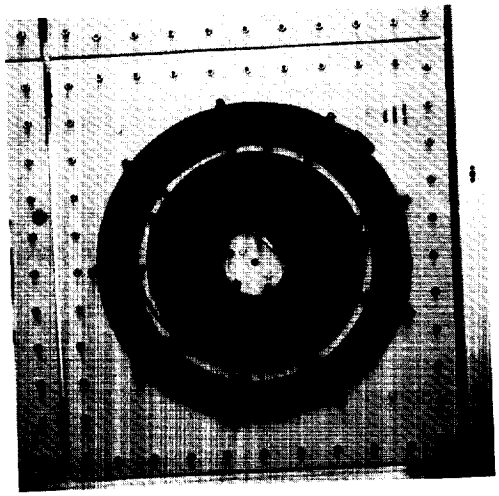

Figure 283
Photo No.: KSC-390C-2204.08
Dup. Neg. No.: L91-9323
LISAR No.: EL-1994-00506
Photo Credit: KSC
Photo Date: 3/22/90
Location: KSC SAEF II
Subject: Postflight Detail of Lower Right of Tray C12

***Figure 284 (Postflight).*** This close-up photograph is of the postretrieval liquid run on the upper right of the cover without cable cover, which is shown in figure 278. Note the extensive brown contamination in the upper center.

Figure 284
Photo No.: KSC-390C-2205.07
Dup. Neg. No.: L91-9334
LISAR No.: EL-1994-00507
Photo Credit: KSC
Photo Date: 3/22/90
Location: KSC SAEF II
Subject: Postflight Detail of Upper Right of Tray C12

***Figure 285 (Postflight).*** This close-up photograph is of the upper center coil, which shows the silicone-rubber spacers under the coil attachment clips. The spacers have changed from clear to brown and have discolored the fiber coils in areas adjacent spacers.

Figure 285
Photo No.: KSC-390C-2205.09
Dup. Neg. No.: L91-9336
LISAR No.: EL-1994-00508
Photo Credit: KSC
Photo Date: 3/22/90
Location: KSC SAEF II
Subject: Postflight Detail of Upper Center Coil of Tray C12

***Figure 286 (Postflight).*** This photograph is of the area beneath the cover without cable. The far side wall and the bottom of the tray appeared wet with brown contamination along the cover edges.

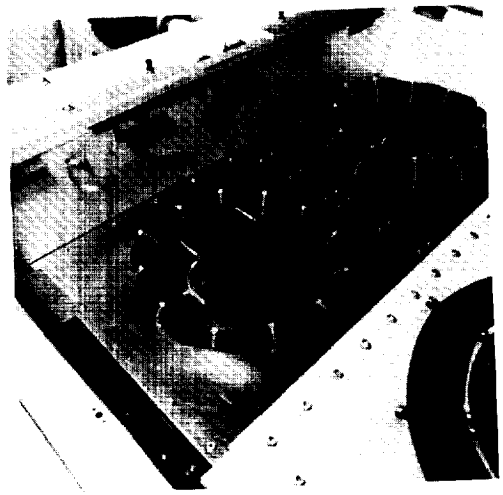

Figure 286
Photo No.: KSC-390C-2210.10
Dup. Neg. No.: L91-9313
LISAR No.: EL-1994-00535
Photo Credit: KSC
Photo Date: 3/22/90
Location: KSC SAEF II
Subject: Postflight Detail of Tray C12

## Tray D1

A High-Resolution Study of Ultraheavy Cosmic Ray Nuclei (UHCRE) (AO178)

Dublin Institute for Advanced Studies ESA at ESTEC

Trays: A2, A4, A10, B5, B7, C5, C6, C8, C11, D1, D5, D7, D11, E2, E10, and F4

See section entitled "Tray D5" and figure 319 for a typical preflight photograph of experiment AO178.

***Figure 287 (In Flight).*** The thermal cover appears to be without physical damage, but it is more taut than in the prelaunch photograph. The glossy blue appearance of the thermal cover in this photograph is apparently caused by the lighting conditions and not by a change in the material optical properties. A few white dots and circular indentations are probably impact on or penetrations of the thermal cover. Velcro attachment pads are evident.

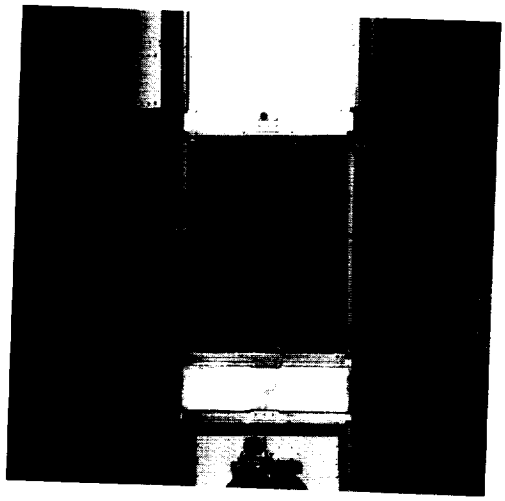

Figure 287
Photo No: S32-89-042
Dup. Neg. No.: L90-10500
LISAR No.: EL-1994-00134
Photo Credit: JSC
Photo Date: 1/12/90
Location: In Flight
Subject: In-Flight Survey of Tray D1

***Figure 288 (Postflight).*** The thermal cover appears specular and no change from in-flight condition is indicated. The bright irregular discoloration located above the grounding strap at about one-third of the height of the thermal cover from the bottom edge did not appear in the in-flight photograph. The discoloration appears to be a piece of material from a degraded experiment that has become attached to the cover. The cover has numerous white dots that may also be debris from other degraded experiments. The cover is less taut than in the in-flight photograph, but the locations of the Velcro attachment pads are still evident.

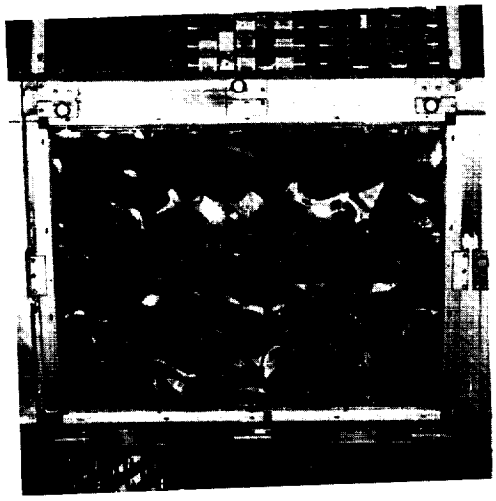

Figure 288
Photo No: KSC-390C-1066.09
Dup. Neg. No.: L90-13478
LISAR No.: EL-1994-00188
Photo Credit: KSC
Photo Date: 2/8/90
Location: KSC SAEF II
Subject: Postflight Survey of Tray D1

***Figure 289 (Postflight).*** This photograph is of the upper left one-sixth of the tray. The thermal cover appears specular with no apparent damage. The reflective properties of the uneven surface of the cover result in various light and color patterns. The locations of the Velcro attachment pads are obvious. A few impact or penetration discolorations and small debris from nearby degraded experiments are visible.

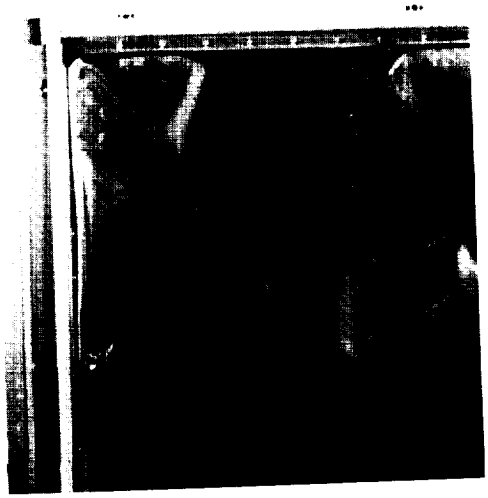

Figure 289
Photo No: KSC-390C-2284.05
Dup. Neg. No.: L91-9292
LISAR No.: EL-1994-00567
Photo Credit: KSC
Photo Date: 3/23/90
Location: KSC SAEF II
Subject: Postflight Detail of Upper Left of Tray D1

***Figure 290 (Postflight).*** This photograph is of the upper center one-sixth of the tray. The thermal cover appears specular with no apparent damage. The reflective properties of the uneven surface of the cover result in various light and color patterns. The locations of the Velcro attachment pads are obvious. A few impact or penetration discolorations and small debris from nearby degraded experiments are visible.

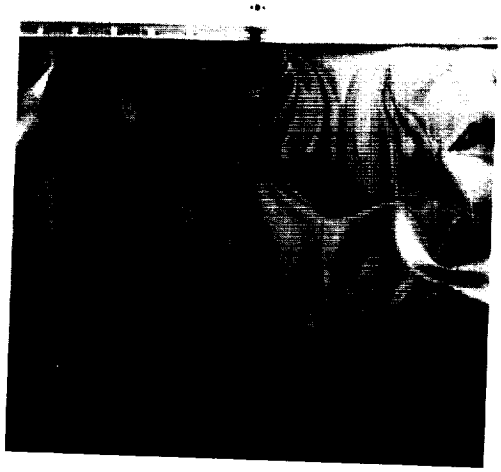

Figure 290
Photo No: KSC-390C-2284.06
Dup. Neg. No.: L91-9293
LISAR No.: EL-1994-00568
Photo Credit: KSC
Photo Date: 3/23/90
Location: KSC SAEF II
Subject: Postflight Detail of Upper Center of Tray D1

***Figure 291 (Postflight).*** This photograph is of the upper right one-sixth of the tray. The thermal cover appears specular with no apparent damage. The reflective properties of the uneven surface of the cover result in various light and color patterns. The locations of the Velcro attachment pads are obvious. A few impact or penetration discolorations and small debris from nearby degraded experiments are visible.

Figure 291
Photo No: KSC-390C-2284.07
Dup. Neg. No.: L91-9294
LISAR No.: EL-1994-00569
Photo Credit: KSC
Photo Date: 3/23/90
Location: KSC SAEF II
Subject: Postflight Detail of Upper Right of Tray D1

***Figure 292 (Postflight).*** This photograph is of the lower left one-sixth of the tray. The thermal cover appears specular with no apparent damage. The reflective properties of the uneven surface of the cover result in various light and color patterns. The locations of the Velcro attachment pads are obvious. A few impact or penetration discolorations and small debris from nearby degraded experiments are visible.

Figure 292
Photo No: KSC-390C-2284.11
Dup. Neg. No.: L91-9298
LISAR No.: EL-1994-00570
Photo Credit: KSC
Photo Date: 3/23/90
Location: KSC SAEF II
Subject: Postflight Detail of Lower Left of Tray D1

***Figure 293 (Postflight).*** This photograph is of the lower center one-sixth of the tray. The thermal cover appears specular. The tear in the lower center of the cover occurred during tray removal. The reflective properties of the uneven surface of the cover result in various light and color patterns. The locations of the Velcro attachment pads are obvious. A few impact or penetration discolorations and small debris from nearby degraded experiments are visible.

Figure 293
Photo No: KSC-390C-2284.12
Dup. Neg. No.: L91-9299
LISAR No.: EL-1994-00571
Photo Credit: KSC
Photo Date: 3/23/90
Location: KSC SAEF II
Subject: Postflight Detail of Lower Center of Tray D1

***Figure 294 (Postflight).*** This photograph is of the lower right one-sixth of the tray. The thermal cover appears specular with no apparent damage. The reflective properties of the uneven surface of the cover result in various light and color patterns. The locations of the Velcro attachment pads are obvious. A few impact or penetration discolorations and small debris from nearby degraded experiments are visible.

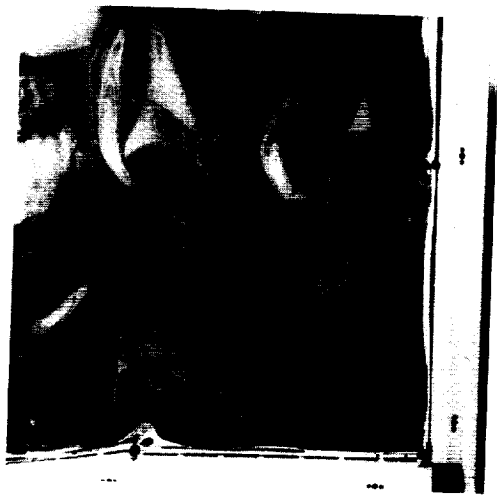

Figure 294
Photo No: KSC-390C-2285.02
Dup. Neg. No.: L91-10156
LISAR No.: EL-1994-00572
Photo Credit: KSC
Photo Date: 3/23/90
Location: KSC SAEF II
Subject: Postflight Detail of Lower Right of Tray D1

## Tray D2

Effects of Solar Radiation on Glasses (AO172)

NASA MSFC

Vanderbilt University

Trays: D2 and G12

The objectives of this experiment were to determine the effects of solar radiation and space environment on glasses.

Study of Factors Determining the Radiation Sensitivity of Quartz Crystal Oscillators (AO189)

Martin Marietta Laboratories

Tray: D2

The objective of this experiment was to determine whether there is a correlation between defect cluster concentrations that were observed in different grades of quartz examined by transmission electron microscope (TEM) and the electrical stability of quartz resonators exposed to the complex radiation of the orbital environment of the LDEF.

Space Debris Impact Experiment (S0001)

NASA LaRC

Trays: A5, A6, A12, B1, B2, B6, B8, B11, C4, C7, D2, D6, E1, E4, E7, E11, F1, F3, F5, F7, F10, F11, G4, G8, and H5

See section entitled "Tray A5" for experiment objective.

***Figure 295 (Preflight).*** Experiment AO172, which was located in the lower left corner of the tray, contained 68 disc-shaped glass samples mounted in Teflon retainers and installed on an aluminum mounting plate that was painted with Chemglaze II A-276 white paint.

Experiment AO189, which was located in the upper left corner, consisted of 14 5-MHz fifth-overtone AT-cut resonators, 10 unshielded hold-down cages, and 4 radiation shields. The experiment was mounted on an aluminum mounting plate in one-sixth of the tray. Ten resonators, in glass cases, are protruding through the open top of the aluminum hold-down cages. The four remaining resonators were shielded from radiation and used as controls. The diagonal white stripes, painted with Chemglaze II A-276 white paint, provided thermal control.

Experiment S0001 consisted of 3/16-in-thick chromic anodized aluminum panels mounted in the right two-thirds of the tray.

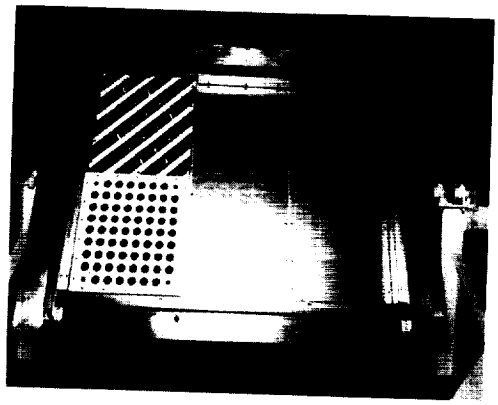

Figure 295
Photo No.: KSC-384C-317.01
Dup. Neg. No.: L84-7158
LISAR No.: EL-1994-00642
Photo Credit: KSC
Photo Date: 1/23/84
Location: KSC SAEF II
Subject: Preflight Survey of Tray D2

***Figure 296 (In Flight).*** The aluminum mounting plate of experiment AO172, which was painted with Chemglaze II A-276 white paint, is now a uniform brown as are the diagonal stripes on experiment AO189. Light reflections appear on the unpainted stripes of experiment AO189. Reflected light obscures any color definition of the panels of experiment S0001.

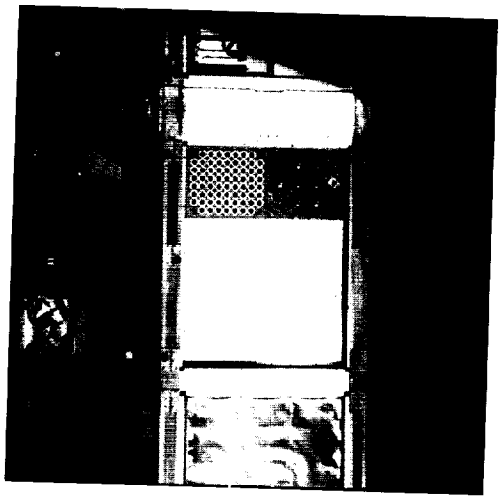

Figure 296
Photo No.: S32-89-013
Dup. Neg. No.: L90-10495
LISAR No.: EL-1994-00130
Photo Credit: JSC
Photo Date: 1/12/90
Location: In Flight
Subject: In-Flight Survey of Tray D2

***Figure 297 (Postflight).*** The surfaces of experiments AO172 and AO189 that were painted with Chemglaze II A-276 white paint are now a uniformly discolored tan. The faint patterns in experiment S0001 panels were observed in preflight.

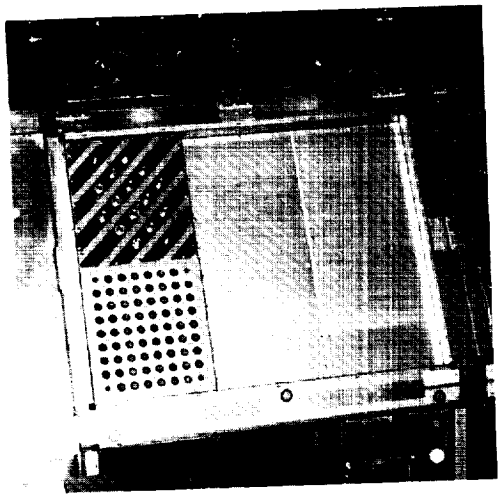

Figure 297
Photo No.: KSC-390C-731.11
Dup. Neg. No.: L92-17662
LISAR No.: EL-1994-00165
Photo Credit: KSC
Photo Date: 2/1/90
Location: KSC O & C building
Subject: Postflight Survey of Tray D2

***Figure 298 (Postflight).*** This photograph is of the upper left one-sixth of the tray. The sensors appear undamaged, but the paint strips that were white before flight are now tan. Light reflections make imperfections in the surface finish that existed before flight more visible.

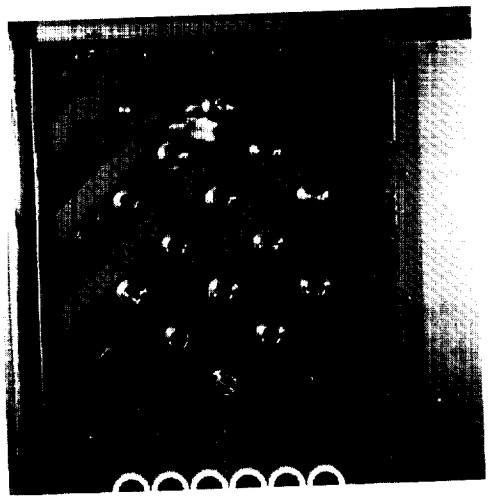

Figure 298
Photo No.: KSC-390C-2038.06
Dup. Neg. No.: L91-9265
LISAR No.: EL-1994-00462
Photo Credit: KSC
Photo Date: 3/16/90
Location: KSC SAEF II
Subject: Postflight Detail of Upper Left of Tray D2

***Figure 299 (Postflight).*** This photograph is of the lower left one-sixth of the tray. The sensors appear undamaged, but the white paint on the baseplate is now tan.

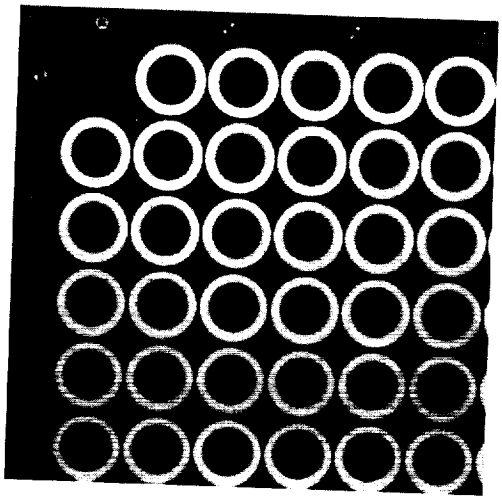

Figure 299
Photo No.: KSC-390C-2038.11
Dup. Neg. No.: L91-9270
LISAR No.: EL-1994-00463
Photo Credit: KSC
Photo Date: 3/16/90
Location: KSC SAEF II
Subject: Postflight Detail of Lower Left of Tray D

## Tray D3

Trapped Proton Energy Spectrum Determination (M0002-1)

Air Force Geophysics Laboratory

NASA MSFC

Army Materials and Mechanics Research Center

Clarkson College of Technology

Emmanuel College

Eastern Kentucky University

Trays: D3, D9, and G12

The objectives of this experiment were to measure the flux and the energy spectrum of protons with energies of 1 to 10 MeV.

Space Environment Effects on Spacecraft Materials (M0003)

The Aerospace Corporation

Trays: D3, D4, D8, and D9

The objective of this experiment was to understand changes in the properties and structure of materials that were exposed to the space environment and to compare these changes with predictions that were based on laboratory experiments.

***Figure 300 (Preflight).*** This figure shows the experiment tray, which is divided into six sections. In the lower right corner is one of three modules for experiment M0002-1. The other five sections of the tray contained experiment M0003, which consisted of coatings, thermal paints, polymers, glasses, composites, semiconductors, and detectors that were examined for data on environmental parameters.

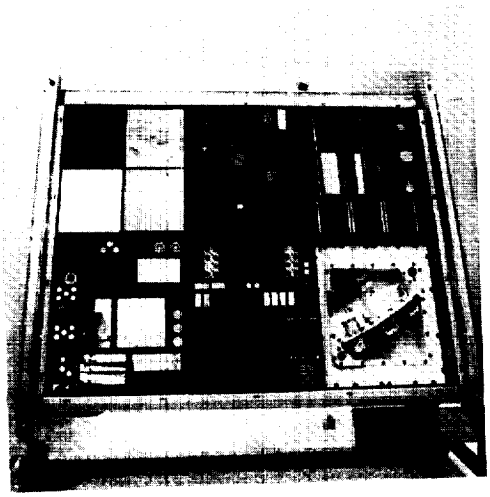

Figure 300
Photo No.:KSC-384C-210.04
Dup. Neg. No.: L89-4385
LISAR No.: EL-1994-00360
Photo Credit: KSC
Photo Date: 1/16/84
Location: KSC SAEF II
Subject: Preflight Survey of Tray D3

***Figure 301 (In Flight).*** Experiment M0003 appears to be in good condition except that approximately half of the thin-film polymers in the lower right tray section are loose at one end. Other material samples seem intact, but they appear discolored. Experiment M0002-1 appears to be without physical damage, but it has a light tan discoloration on the detector housings and the surfaces of the experiment support structure.

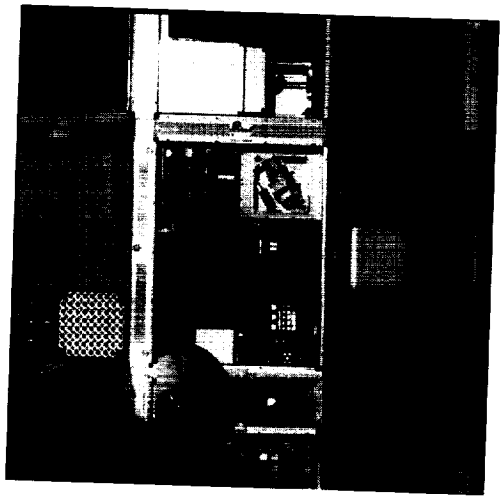

Figure 301
Photo No.: S32-89-008
Dup. Neg. No.: L90-10494
LISAR No.: EL-1994-00129
Photo Credit: JSC
Photo Date: 1/12/90
Location: In Flight
Subject: In-Flight Survey of Tray D3

***Figure 302 (Postflight).*** No significant differences from in-flight conditions are apparent. Many experiment specimens and mounting hardware are discolored. The damaged thin-film polymers in the lower left are still attached. Other parts of the experiments appear intact.

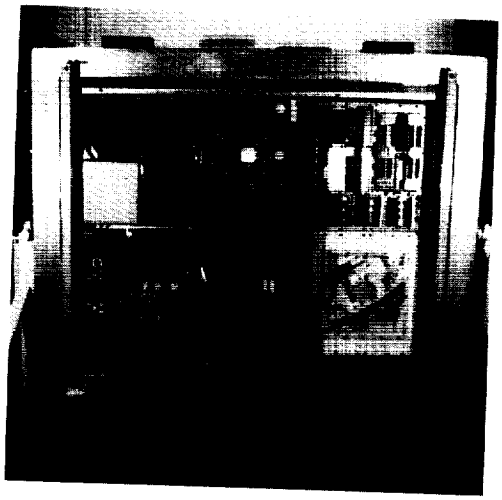

Figure 302
Photo No.: KSC-390C-1485.05
Dup. Neg. No.: L91-9252
LISAR No.: EL-1994-00210
Photo Credit: KSC
Photo Date: 2/28/90
Location: KSC SAEF II
Subject: Postflight Survey of Tray D3

***Figure 303 (Postflight).*** This photograph is of the upper left one-sixth of the tray. The metallized and coated polymers appear to have survived the exposure intact, but discolorations are apparent.

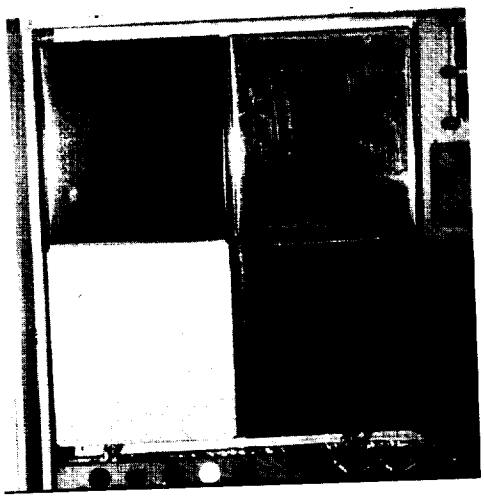

Figure 303
Photo No.: KSC-390C-1485.06
Dup. Neg. No.: L91-9253
LISAR No.: EL-1994-00064
Photo Credit: KSC
Photo Date: 2/28/90
Location: KSC SAEF II
Subject: Postflight Detail of Upper Left of Tray D3

***Figure 304 (Postflight).*** This photograph is of the upper center one-sixth of the tray. Most test specimens appear intact, but there appears to be significant brown discoloration on specimens and specimen mounting hardware. Composite material samples located in upper right, upper center, and lower center remain intact, but they are bleached or discolored.

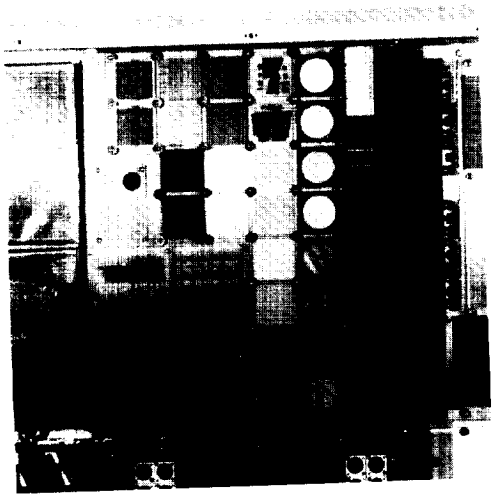

Figure 304
Photo No.: KSC-390C-1485.07
Dup. Neg. No.: L91-9254
LISAR No.: EL-1994-00065
Photo Credit: KSC
Photo Date: 2/28/90
Location: KSC SAEF II
Subject: Postflight Detail of Upper Center of Tray D3

***Figure 305 (Postflight).*** This photograph is of the upper right one-sixth of the tray. Most test specimens appear intact, but there seems to be significant brown discoloration on specimens and specimen mounting hardware. Composite material samples located in upper right, upper center, and lower center remain intact, but they are bleached or discolored.

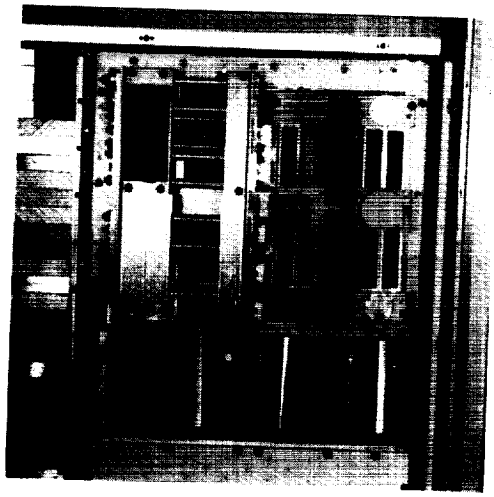

Figure 305
Photo No.: KSC-390C-1485.08
Dup. Neg. No.: L91-9255
LISAR No.: EL-1994-00066
Photo Credit: KSC
Photo Date: 2/28/90
Location: KSC SAEF II
Subject: Postflight Detail of Upper Right of Tray D3

***Figure 306 (Postflight).*** This photograph is of the lower left one-sixth of the tray. Many of the thin-film polymers are loose at one end. The Teflon covers and the large square and the rectangle in the center appear to remain intact; however, they have changed from silver to milky white where components are located beneath them and to a gold color where there are no components. Surfaces and mounting hardware appear to have significant brown discoloration.

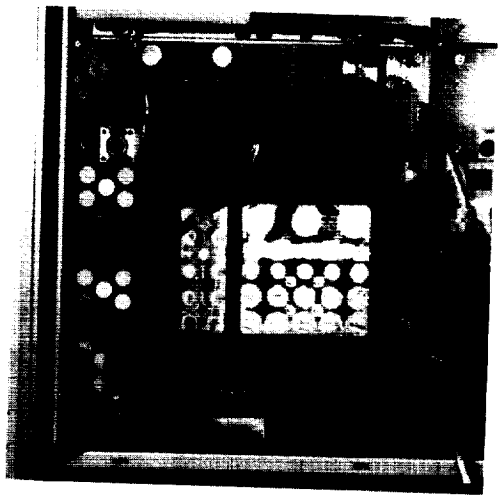

Figure 306
Photo No.: KSC-390C-1485.09
Dup. Neg. No.: L91-9256
LISAR No.: EL-1994-00067
Photo Credit: KSC
Photo Date: 2/28/90
Location: KSC SAEF II
Subject: Postflight Detail Survey of Lower Left of Tray D3

***Figure 307 (Postflight).*** This photograph is of the lower center one-sixth of the tray. Most test samples appear intact, but samples and mounting hardware have extensive discolorations. Composite material samples that are located in the upper right, the upper center, and the lower center remain intact, but they are bleached or discolored.

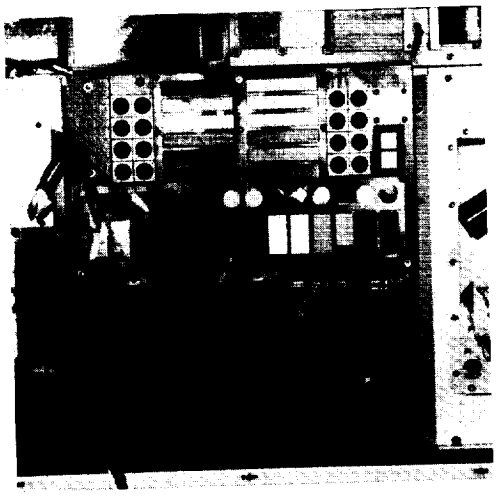

Figure 307
Photo No.: KSC-390C-1485.10
Dup. Neg. No.: L91-9257
LISAR No.: EL-1994-00093
Photo Credit: KSC
Photo Date: 2/28/90
Location: KSC SAEF II
Subject: Postflight Detail Survey of Lower Center of Tray D3

***Figure 308 (Postflight).*** Experiment M0002-1 in the lower right one-sixth of the tray appears intact, but it is a somewhat uniform tan rather than white, which was the color it was painted before flight.

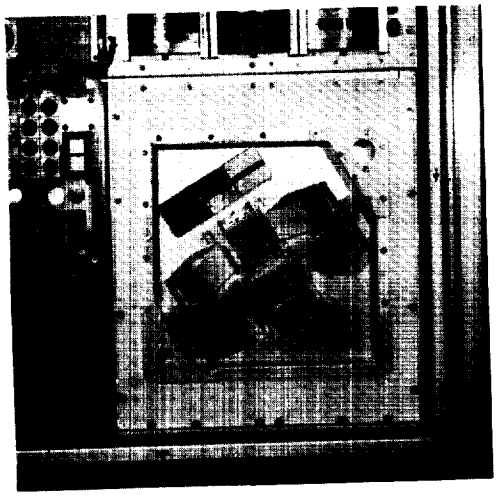

Figure 308
Photo No.: KSC-390C-1485.11
Dup. Neg. No.: L91-9258
LISAR No.: EL-1994-00094
Photo Credit: KSC
Photo Date: 2/28/90
Location: KSC SAEF II
Subject: Postflight Detail of Lower Right of Tray D3

## Tray D4

Space Environment Effects on Spacecraft Materials (M0003)

The Aerospace Corporation

Trays: D3, D4, D8, and D9

The objective of this experiment was to understand changes in the properties and the structure of materials that were exposed to the space environment and to compare these changes with predictions that were based on laboratory experiments.

***Figure 309 (Preflight).*** The experiment tray was divided into three sections. The right section provided space for the EPDS. The center section accommodated the signal conditioning unit (SCU) and an experiment mounting plate, which was populated with composite material samples on an aluminum substructure. The left section housed the EECC with a complement of experiment samples consisting of coatings, thermal paints, polymers, glasses, and semiconductors. Detectors within the experiment provide environmental data for use in postflight analyses. In this figure, the EPDS cover has a white thermal control paint (Chemglaze II A-276). The SCU cover is also coated with a white thermal control paint, IITRI S13GLO, and the EECC is covered with a chromic anodized aluminum thermal cover.

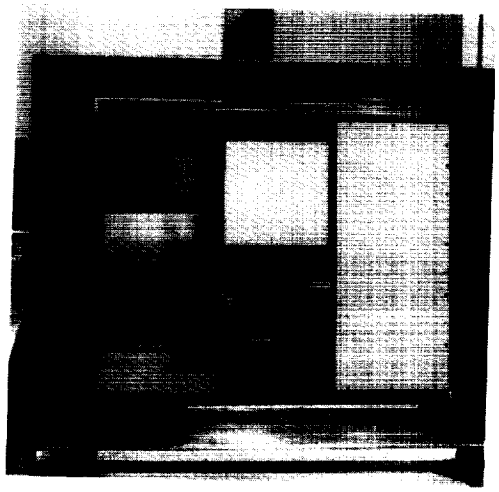

Figure 309
Photo No.: KSC-384C-210.01
Dup. Neg. No.: L89-4382
LISAR No.: EL-1994-00359
Photo Credit: KSC
Photo Date: 1/16/84
Location: KSC SAEF II
Subject: Preflight Survey of Tray D4

***Figure 310 (In Flight).*** The Chemglaze II A-276 white paint on the EPDS cover has changed to a medium brown and the IITRI S13G-LO white paint has become light tan or off-white. Colors of the composite material samples are bright and clear. Some material samples appear to be blue in this photograph, although they did not in prelaunch or postflight photographs. The mounting plate of the composite materials experiment has discolorations that vary from a light tan to a medium brown. The rectangular aluminum cover plate located in the upper center of the experiment is a uniform light brown. The thermal covers on the EECC appear to have changed to lavender or purple in this photograph; however the covers maintain the color of anodized aluminum in postflight photos. The dark square discolorations on the upper corners of the thermal cover are pads of tape used to cover exposed sharp corners. The pads were not in place in the prelaunch photograph.

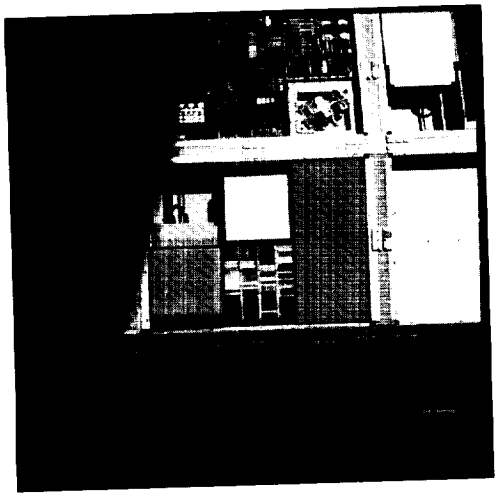

Figure 310
Photo No.: S32-89-004
Dup. Neg. No.: L90-10493
LISAR No.: EL-1994-00128
Photo Credit: JSC
Photo Date: 1/12/90
location: In Flight
Subject: In-Flight Survey of Tray D4

***Figure 311 (Postflight).*** Light reflections cause details to be less clear than in the in-flight photograph. The painted covers are discolored and the composite materials experiment mounting plate has discolorations that vary from light tan to medium brown.

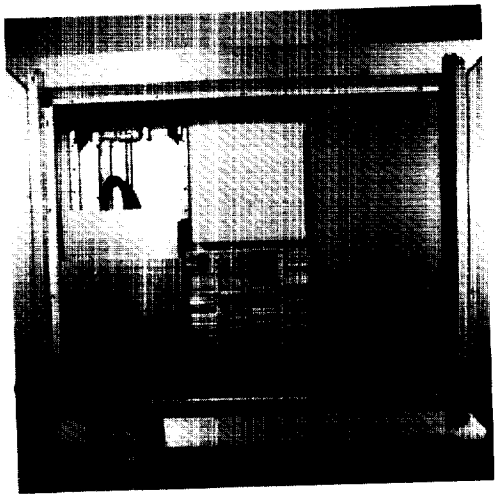

Figure 311
Photo No.: KSC-390C-1478.03
Dup. Neg. No.: L91-9173
LISAR No.: EL-1994-00202
Photo Credit: KSC
Photo Date: 2/28/90
Location: KSC SAEF II
Subject: Postflight Survey of Tray D4

***Figure 312 (Postflight).*** This photograph is of the upper center one-sixth of the tray. The signal conditioning unit thermal cover that was painted with IITRI S13G-LO white paint has become light tan or off-white.

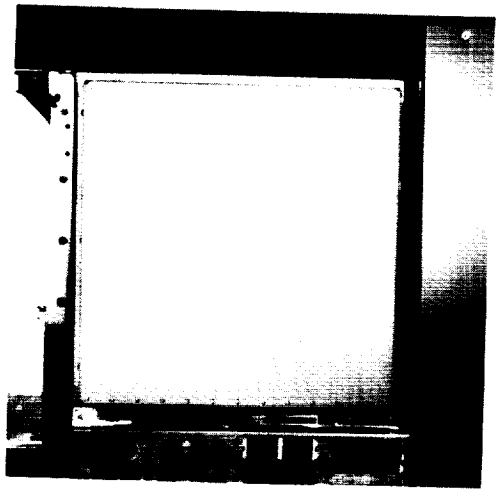

Figure 312
Photo No.: KSC-390C-1478.07
Dup. Neg. No.: L91-9177
LISAR No.: EL-1994-00034
Photo Credit: KSC
Photo Date: 2/28/90
Location: KSC SAEF II
Subject: Postflight Detail of Upper Center of Tray D4

***Figure 313 (Postflight).*** This photograph is of the upper right one-sixth of the tray. The Chemglaze II A-276 white paint on the EPDS cover has turned from white to uniform brown.

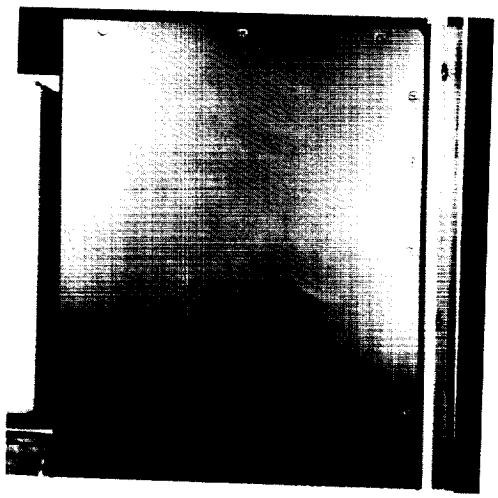

Figure 313
Photo No.: KSC-390C-1478.08
Dup. Neg. No.: L91-9178
LISAR No.: EL-1994-00035
Photo Credit: KSC
Photo Date: 2/28/90
Location: KSC SAEF II
Subject: Postflight Detail of Upper Right of Tray D4

***Figure 314 (Postflight).*** This photograph is of the lower center one-sixth of the tray. Many test specimens have changed color and some show signs of degradation. Some mounting hardware shows discoloration.

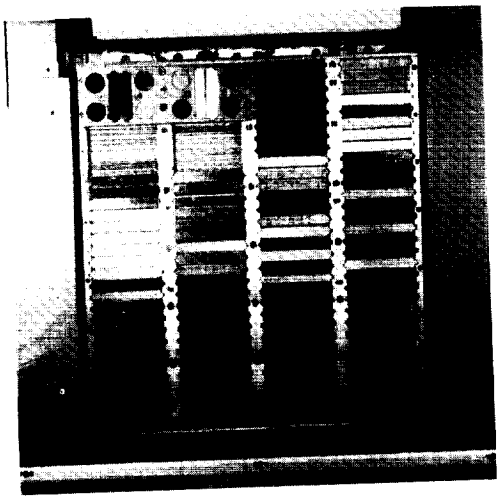

Figure 314
Photo No.: KSC-390C-1478.12
Dup. Neg. No.: L91-9182
LISAR No.: EL-1994-00036
Photo Credit: KSC
Photo Date: 2/28/90
Location: KSC SAEF II
Subject: Postflight Detail of Lower Center of Tray D4

***Figure 315 (Postflight).*** This close-up photograph is of the upper left of the lower center one-sixth of the tray. Many test specimens have changed color and some show signs of degradation. Some mounting hardware shows discoloration.

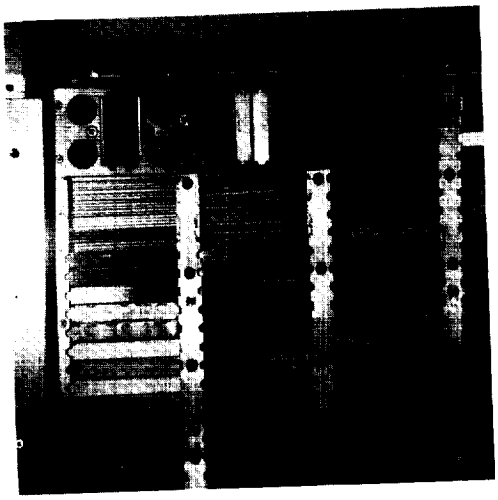

Figure 315
Photo No.: KSC-390C-1480.07
Dup. Neg. No.: L91-9189
LISAR No.: EL-1994-00046
Photo Credit: KSC
Photo Date: 2/28/90
Location: KSC SAEF II
Subject: Postflight Detail of Upper Left of Lower Center of Tray D4

***Figure 316 (Postflight).*** This close-up photograph is of the upper right of the lower center one-sixth of the tray. Many test specimens have changed color and some show signs of degradation. Some mounting hardware shows discoloration. The colors in the upper left area are somewhat washed out because of the lighting.

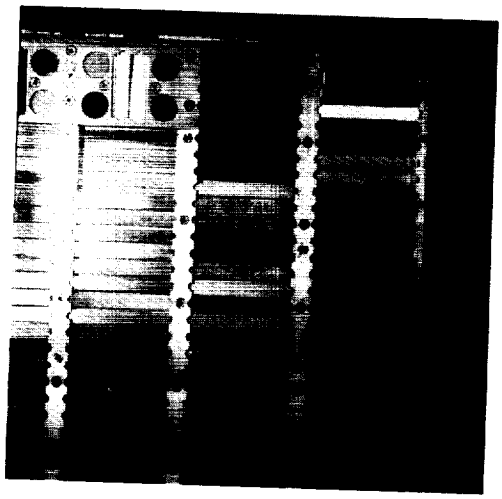

Figure 316
Photo No.: KSC-390C-1480.09
Dup. Neg. No.: L91-9191
LISAR No.: EL-1994-00047
Photo Credit: KSC
Photo Date: 2/28/90
Location: KSC SAEF II
Subject: Postflight Detail of Upper Right of Lower Center of Tray D4

***Figure 317 (Postflight).*** This close-up photograph is of the lower left of the lower center one-sixth of the tray. Many test specimens have changed color and some show signs of degradation. Some mounting hardware shows discoloration.

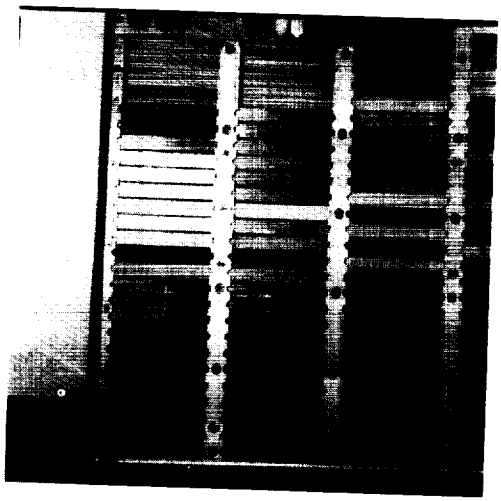

Figure 317
Photo No.: KSC-390C-1480.11
Dup. Neg. No.: L91-9193
LISAR No.: EL-1994-00048
Photo Credit: KSC
Photo Date: 2/28/90
Location: KSC SAEF II
Subject: Postflight Detail of Lower Left of Lower Center of Tray D4

***Figure 318 (Postflight).*** This close-up photograph is of the lower right of the lower center one-sixth of the tray. Many test specimens have changed color and some show signs of degradation. Some mounting hardware shows discoloration.

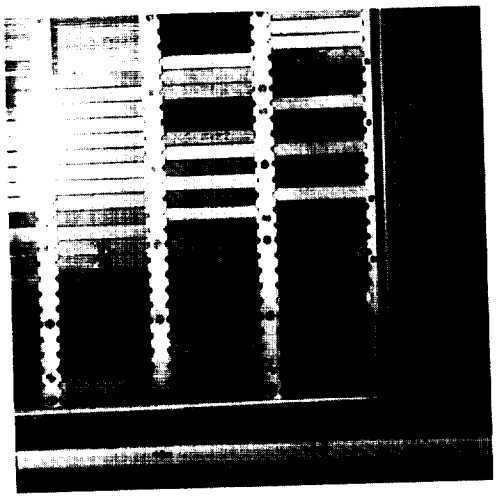

Figure 318
Photo No.: KSC-390C-1482.03
Dup. Neg. No.: L91-9156
LISAR No.: EL-1994-00050
Photo Credit: KSC
Photo Date: 2/28/90
Location: KSC SAEF II
Subject: Postflight Detail of Lower Right of Lower Center of Tray D4

## Tray D5

A High-Resolution Study of Ultraheavy Cosmic Ray Nuclei (UHCRE) (AO178)

Dublin Institute for Advanced Studies

ESA at ESTEC

Trays: A2, A4, A10, B5, B7, C5, C6, C8, C11, D1, D5, D7, D11, E2, E10, and F4

The main objective of this experiment was to determine the relative abundance of cosmic ray nuclei with a charge greater than Z = 65 atomic number near Earth.

***Figure 319 (Preflight).*** Each tray of experiment AO178 contained three cylindrical pressure vessels, each of which was filled with a foam insert that housed four detector stacks. Each tray was covered with a 5-mil silvered Teflon thermal control cover. The cover was supported by an aluminum frame, which was an integral part of the experiment structure. The cover was held in place by Velcro pads that were selectively located on the frame and on the back of the cover. The silvered Teflon thermal cover, because it was highly reflective, mirrored images, lights, and colors from the surrounding area. The strip extending over the lower flange was a copper-coated pressure-sensitive tape that provided an electrical ground between the thermal cover of the experiment and the LDEF structure. (This preflight photograph is typical for experiment AO178.)

Figure 319
Photo No.: KSC-384C-60.02
Dup. Neg. No.: L84-7040
LISAR No.: EL-1994-00346
Photo Credit: KSC
Photo Date: 1/17/84
Location: KSC SAEF II
Subject: Preflight Survey of Tray D5

***Figure 320 (In Flight).*** The thermal cover appears to be without physical damage, but it is more taut than in the prelaunch photograph. The glossy blue-black appearance of the thermal cover in this photograph is due to lighting conditions and not to a change in the material optical properties. The oblong indentations in the thermal cover are in areas where Velcro pads are bonded to the back of the cover. The irregular discolorations on the cover surface are from lighting and reflections. The white dots and the circular indents in the right center of the cover may be impact locations. The ground strap appears to be in place and to have no visible damage.

Figure 320
Photo No.: S32-82-017
Dup. Neg. No.: L90-10456
LISAR No.: EL-1994-00038
Photo Credit: JSC
Photo Date: 1/12/90
Location: In Flight
Subject: In-Flight Survey of Tray D5

***Figure 321 (Postflight).*** The thermal cover appears specular with no apparent damage. A vertical strip of discoloration that is approximately 6-in. wide with a grainy pattern extends from top to bottom along the left side of the thermal cover. This discoloration was visible prior to flight. The cover appears less taut than in the in-flight photograph and locations of the Velcro attachment pads are not as prominent. The ground strap appears to be in place with no visible damage; however, the color appears darker than in the prelaunch photograph.

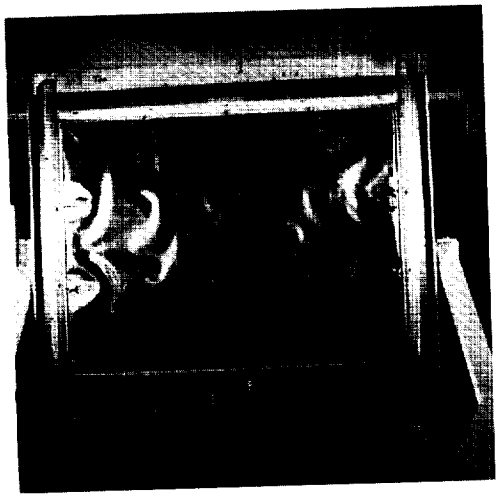

Figure 321
Photo No.: KSC-390C-2277.10
Dup. Neg. No.: L91-10204
LISAR No.: EL-1994-00311
Photo Credit: KSC
Photo Date: 3/23/90
Location: KSC SAEF II
Subject: Postflight Survey of Tray D5

***Figure 322 (Postflight).*** This photograph is of the upper left one-sixth of the tray. The grainy pattern in the surface finish, which is visible in the light reflection was on the material prior to flight. The thermal cover appears specular with no apparent damage. The reflective properties of the uneven surface of the cover result in various light and color patterns. The locations of the Velcro attachment pads are visible.

Figure 322
Photo No.: KSC-390C-2277.11
Dup. Neg. No.: L91-10205
LISAR No.: EL-1994-00543
Photo Credit: KSC
Photo Date: 3/23/90
Location: KSC SAEF II
Subject: Postflight Detail of Upper Left of Tray D5

***Figure 323 (Postflight).*** This photograph is of the upper center one-sixth of the tray. The thermal cover appears specular with no apparent damage. The reflective properties of the uneven surface of the cover result in various light and color patterns. The locations of the Velcro attachment pads are visible.

Figure 323
Photo No.: KSC-390C-2277.12
Dup. Neg. No.: L91-10206
LISAR No.: EL-1994-00544
Photo Credit: KSC
Photo Date: 3/23/90
Location: KSC SAEF II
Subject: Postflight Detail of Upper Center of Tray D5

***Figure 324 (Postflight).*** This photograph is of the upper right one-sixth of the tray. The thermal cover appears specular with no apparent damage. The reflective properties of the uneven surface of the cover result in various light and color patterns. The locations of the Velcro attachment pads are visible.

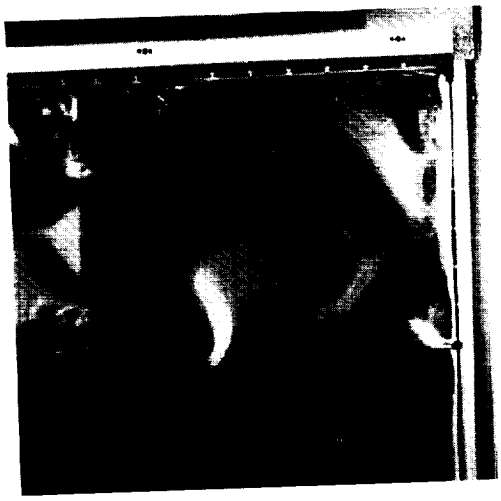

Figure 324
Photo No.: KSC-390C-2279.02
Dup. Neg. No.: L91-10208
LISAR No.: EL-1994-00545
Photo Credit: KSC
Photo Date: 3/23/90
Location: KSC SAEF II
Subject: Postflight Detail of Upper Right of Tray D5

***Figure 325 (Postflight).*** This photograph is of the lower left one-sixth of the tray. The thermal cover appears specular with no apparent damage. The grainy pattern in the surface finish, which is visible in the light reflection, was on the material prior to flight. The reflective properties of the uneven surface of the cover result in various light and color patterns. The locations of the Velcro attachment pads are visible.

Figure 325
Photo No.: KSC-390C-2279.06
Dup. Neg. No.: L91-10212
LISAR No.: EL-1994-00546
Photo Credit: KSC
Photo Date: 3/23/90
Location: KSC SAEF II
Subject: Postflight Detail of Lower Left of Tray D5

***Figure 326 (Postflight).*** This photograph is of the lower center one-sixth of the tray. The thermal cover appears specular with no apparent damage. The reflective properties of the uneven surface of the cover result in various light and color patterns. The locations of the Velcro attachment pads are visible.

Figure 326
Photo No.: KSC-390C-2279.07
Dup. Neg. No.: L91-10213
LISAR No.: EL-1994-00547
Photo Credit: KSC
Photo Date: 3/23/90
Location: KSC SAEF II
Subject: Postflight Detail of Lower Center of Tray D5

***Figure 327 (Postflight).*** This photograph is of the lower right one-sixth of the tray. The thermal cover appears specular with no apparent damage. The reflective properties of the uneven surface of the cover result in various light and color patterns. The locations of the Velcro attachment pads are visible.

Figure 327
Photo No.: KSC-390C-2279.08
Dup. Neg. No.: L91-10214
LISAR No.: EL-1994-00559
Photo Credit: KSC
Photo Date: 3/23/90
Location: KSC SAEF II
Subject: Postflight Detail of Lower Right of Tray D5

## Tray D6

Interplanetary Dust Experiment (IDE) (AO201)

Institute for Space Science and Technology

NASA LaRC

North Carolina State University

Trays: B12, C3, C9, D6, G10, and H11

The objective of this experiment was to study interplanetary dust and obtain information about particle mass and velocity.

Space Debris Impact Experiment (S0001)

NASA LaRC

Trays: A5, A6, A12, B1, B2, B6, B8, B11, C4, C7, D2, D6, E1, E4, E7, E11, F1, F3, F5, F7, F10, F11, G4, G8, and H5

See section entitled "Tray A5" for experiment objective.

***Figure 328 (Preflight).*** This prelaunch photograph shows two experiments in an integrated tray. Experiment S0001 is passive and uses the left two-thirds of the exposed surface area. It consists of two 3/16-in-thick chromic anodized aluminum panels.

Experiment AO201 is an active experiment that is located in the right one-third of the tray. Experiment AO201 exposed 80 metal-oxide-silicon (MOS) capacitor-type impact sensors and is shown in figure 211. The different colors are the reflection of several of the technicians and a clean room work bench.

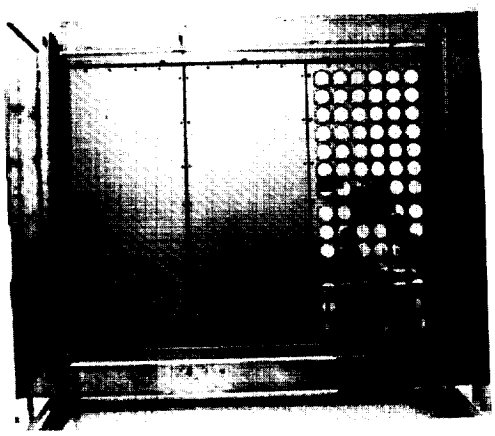

Figure 328
Photo No.: KSC-384C-15.10
Dup. Neg. No.: L84-7024
LISAR No.: EL-1994-00333
Photo Credit: KSC
Photo Date: 1/9/84
Location: KSC SAEF II
Subject: Preflight Survey of Tray D6

***Figure 329 (In Flight).*** During the mission, the tray surface was at an angle of approximately 82° to the orbital velocity vector, and therefore it was exposed to a higher atomic oxygen flux than if it had been parallel with the velocity vector. Note the difference in color of the paint dots on the tray clampblocks; there are white dots along the top edge, a light tan dot in the center, and dark brown dots along the bottom of the photograph. This color change illustrates the transition from the leading to the trailing sides. Experiment AO201, which is located in the left side of the tray, seems to have a thin coat of the brown contamination stain. The detectors show reflections of the sky and the cargo bay liner in the mirrorlike surfaces. The SDI plates show fingerprints and a palm print that occurred during installation of the panels. These prints are not visible on the preflight photograph.

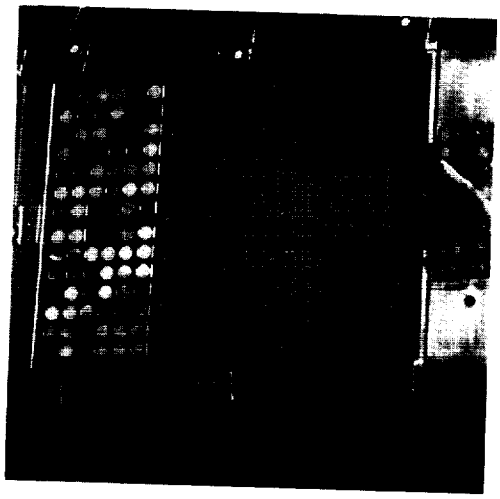

Figure 329
Photo No.: S32-82-009
Dup. Neg. No.: L91-10455
LISAR No.: EL-1994-00056
Photo Credit: JSC
Photo Date: 1/12/90
Location: In Flight
Subject: In-Flight Survey of Tray D6

***Figure 330 (Postflight).*** The direction and the intensity of the artificial light source caused reflections that tended to wash out the brown stain on the aluminum structure. Experiment AO201 appears to be in excellent condition in the postflight photograph. All bond joints seem to have survived the space environment and the experiment hardware is intact. The blue in the metallic surface of the detectors is caused by reflections of the surrounding area. The white stripe running diagonally across the bottom two rows of detectors is the reflection of a safety control rope that restricted access to the LDEF.

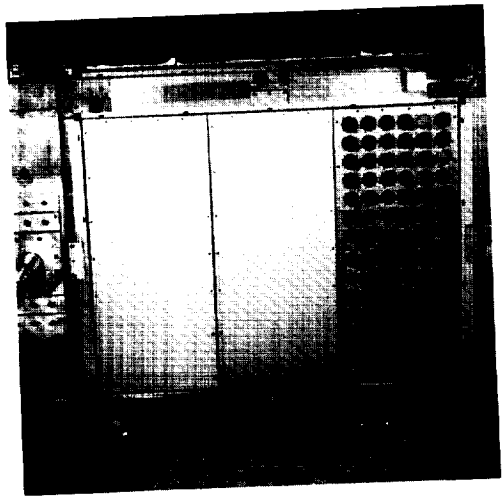

Figure 330
Photo No.: KSC-390C-1033.10
Dup. Neg. No.: L90-13440
LISAR No.: EL-1994-00180
Photo Credit: KSC
Photo Date: 2/9/90
Location: KSC SAEF II
Subject: Postflight Survey of Tray D6

***Figure 331 (Postflight).*** This photograph is of the upper right one-sixth of the tray. The different colors of the detectors are due to reflections of surrounding areas. Some small impacts on the sensors are visible. There is some discoloration of the mounting hardware and the baseplate.

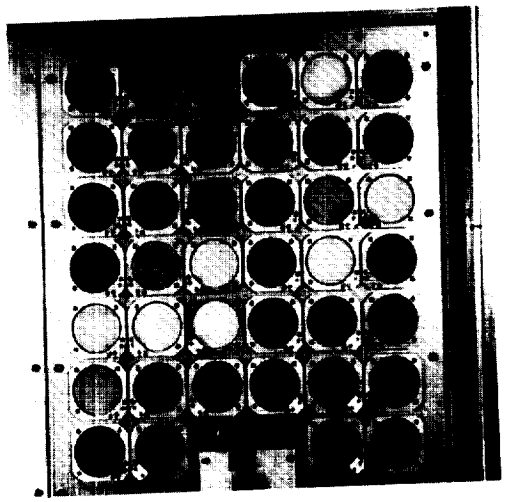

Figure 331
Photo No.: KSC-390C-2070.11
Dup. Neg. No.: L91-10235
LISAR No.: EL-1994-00479
Photo Credit: KSC
Photo Date: 3/19/90
Location: KSC SAEF II
Subject: Postflight Detail of Upper Right of Tray D6

***Figure 332 (Postflight).*** This photograph is of the lower right one-sixth of the tray. The different colors of the detectors are due to reflections of surrounding areas. Some small impacts on the sensors are visible. There is some discoloration of the mounting hardware and baseplate.

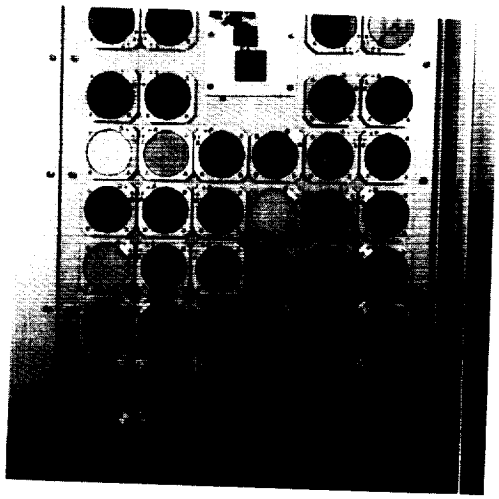

Figure 332
Photo No.: KSC-390C-2070.12
Dup. Neg. No.: L91-10236
LISAR No.: EL-1994-00480
Photo Credit: KSC
Photo Date: 3/19/90
Location: KSC SAEF II
Subject: Postflight Detail of Lower Right of Tray D6

***Figure 333 (Postflight).*** This oblique view photograph is of the upper right one-sixth of the tray. The different colors of the detectors are due to reflections of the surrounding areas. Note the reflection of the tray restraining bar in the surface of the right row of detectors.

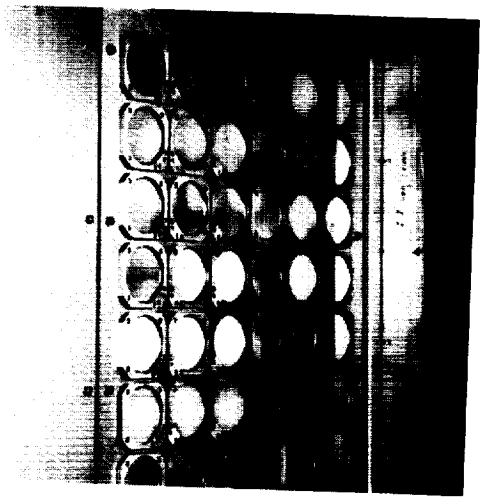

Figure 333
Photo No.: KSC-390C-2071.02
Dup. Neg. No.: L91-10238
LISAR No.: EL-1994-00481
Photo Credit: KSC
Photo Date: 3/19/90
Location: KSC SAEF II
Subject: Postflight Detail of Upper Right of Tray D6

***Figure 334 (Postflight).*** This oblique view photograph is of the lower right one-sixth of the tray. The different colors of the detectors are due to reflections of the surrounding areas. Note the reflection of the tray restraining bar in the surface of the right row of detectors.

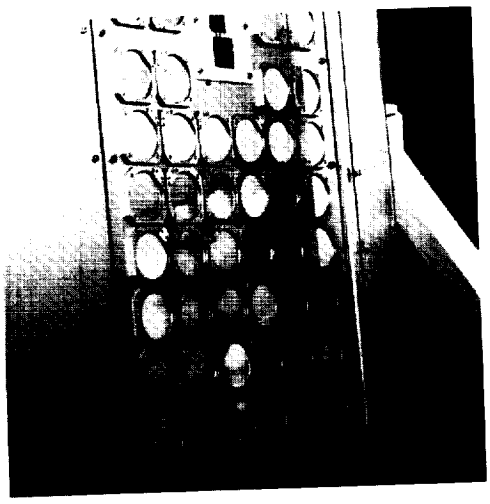

Figure 334
Photo No.: KSC-390C-2071.03
Dup. Neg. No.: L91-10239
LISAR No.: EL-1994-00482
Photo Credit: KSC
Photo Date: 3/19/90
Location: KSC SAEF II
Subject: Postflight Detail of Lower Right of Tray D6

***Figure 335 (Postflight).*** This close-up photograph is of a sensor and shows an impact crater. The sensor is located at the lower left corner of the solar cell baseplate. Other areas on the sensor also indicate impacts.

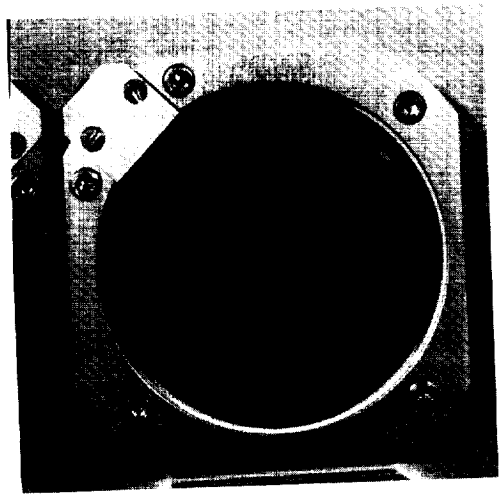

Figure 335
Photo No.: KSC-390C-2071.04
Dup. Neg. No.: L91-10240
LISAR No.: EL-1994-00483
Photo Credit: KSC
Photo Date: 3/19/90
Location: KSC SAEF II
Subject: Postflight Detail of Tray D6

## Tray D7

A High-Resolution Study of Ultraheavy Cosmic Ray Nuclei (UHCRE) (AO178)

Dublin Institute for Advanced Studies

ESA at ESTEC

Trays: A2, A4, A10, B5, B7, C5, C6, C8, C11, D1, D5, D7, D11, E2, E10, and F4

See section entitled "Tray D5" and figure 319 for a typical preflight photograph of experiment AO178.

***Figure 336 (In Flight).*** The thermal cover is without physical damage and is taut. The blue appearance of the thermal cover in this photograph is due to lighting conditions and not a change in the material optical properties. The oblong indentations in the thermal cover surface are areas where Velcro attachment pads are bonded to the back of the cover. The surface of the thermal cover appears to have small light blue circular discolorations of various sizes that appear to be impacts. The white irregular shapes in the photograph are light reflections from the edges of indentations in the cover surface. The scalloped edge along the left side of the thermal cover occurs between attachment pads. The ground strap is in place with no visible damage, but it also appears to be a deeper copper color than in the prelaunch photograph.

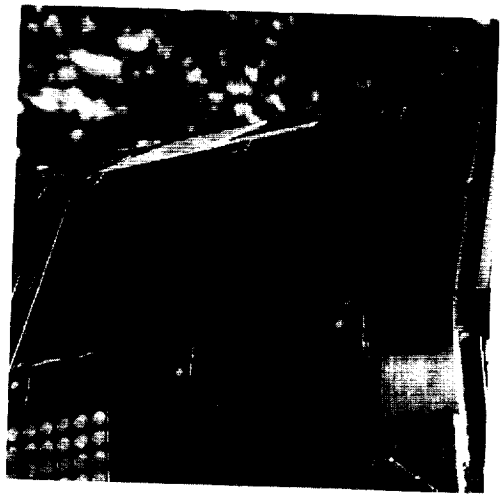

Figure 336
Photo No.: S32-82-050
Dup. Neg. No.: L90-10464
LISAR No.: EL-1994-00062
Photo Credit: JSC
Photo Date: 1/12/90
Location: In Flight
Subject: In-Flight Survey of Tray D7

***Figure 337 (Postflight).*** The surface of the thermal cover appears specular with green and white discolorations from photographic lights and reflections of the surrounding area. The black or brown dots are impacts or penetrations. The cover is not as taut as in the in-flight photograph and locations of the Velcro attachment pads are not as prominent. The ground strap has no apparent physical damage, but it is a darker copper color than in the prelaunch photograph.

Figure 337
Photo No.: KSC-390C-1472.02
Dup. Neg.: L91-10248
LISAR No.: EL-1994-00207
Photo Credit: KSC
Photo Date: 2/26/90
Location: KSC SAEF II
Subject: Postflight Survey of Tray D7

***Figure 338 (Postflight).*** This photograph is of the upper left one-sixth of the tray. The thermal cover appears specular with some small discolored impacts or penetrations. The reflective properties of the uneven surface of the cover result in various light and color patterns. The locations of the Velcro attachment pads are obvious.

Figure 338
Photo No.: KSC-390C-1472.09
Dup. Neg. No.: L91-10255
LISAR No.: EL-1994-00194
Photo Credit: KSC
Photo Date: 2/26/90
Location: KSC SAEF II
Subject: Postflight Detail of Upper Left of Tray D7

***Figure 339 (Postflight).*** This photograph is of the upper center one-sixth of the tray. The thermal cover appears specular with some small discolored impacts or penetrations. The reflective properties of the uneven surface of the cover result in various light and color patterns. The locations of the Velcro attachment pads are obvious.

Figure 339
Photo No.: KSC-390C-1472.10
Dup. Neg. No.: L91-10256
LISAR No.: EL-1994-00195
Photo Credit: KSC
Photo Date: 2/26/90
Location: KSC SAEF II
Subject: Postflight Detail of Upper Center of Tray D7

***Figure 340 (Postflight).*** This photograph is of the upper right one-sixth of the tray. The thermal cover appears specular with some small discolored impacts or penetrations. The reflective properties of the uneven surface of the cover result in various light and color patterns. The locations of the Velcro attachment pads are obvious.

Figure 340
Photo No.: KSC-390C-1472.11
Dup. Neg. No.: L91-10257
LISAR No.: EL-1994-00196
Photo Credit: KSC
Photo Date: 2/26/90
Location: KSC SAEF II
Subject: Postflight Detail of Upper Right of Tray D7

***Figure 341 (Postflight).*** This photograph is of the lower left one-sixth of the tray. The thermal cover appears specular with some small discolored impacts or penetrations. The reflective properties of the uneven surface of the cover result in various light and color patterns. The locations of the Velcro attachment pads are obvious.

Figure 341
Photo No.: KSC-390C-1473.04
Dup. Neg. No.: L91-10262
LISAR No.: EL-1994-00208
Photo Credit: KSC
Photo Date: 2/26/90
Location: KSC SAEF II
Subject: Postflight Detail of Lower Left of Tray D7

***Figure 342 (Postflight).*** This photograph is of the lower center one-sixth of the tray. The thermal cover appears specular with some small discolored impacts or penetrations. The reflective properties of the uneven surface of the cover result in various light and color patterns. The locations of the Velcro attachment pads are obvious.

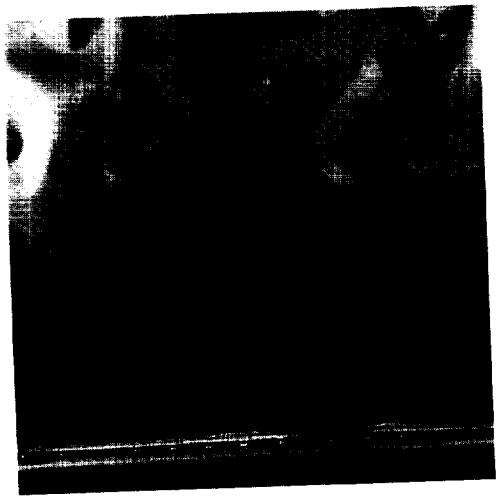

Figure 342
Photo No.: KSC-390C-1473.05
Dup. Neg. No.: L91-10263
LISAR No.: EL-1994-00209
Photo Credit: KSC
Photo Date: 2/26/90
Location: KSC SAEF II
Subject: Postflight Detail of Lower Center of Tray D7

***Figure 343 (Postflight).*** This photograph is of the lower right one-sixth of the tray. The thermal cover appears specular with some small discolored impacts or penetrations. The reflective properties of the uneven surface of the cover result in various light and color patterns. The locations of the Velcro attachment pads are obvious.

Figure 343
Photo No.: KSC-390C-1473.06
Dup. Neg. No.: L91-10264
LISAR No.: EL-1994-00033
Photo Credit: KSC
Photo Date: 2/26/90
Location: KSC SAEF II
Subject: Postflight Detail of Lower Right of Tray D7

## Tray D8

Space Environment Effects on Spacecraft Materials (M0003)

The Aerospace Corporation

Trays: D3, D4, D8, and D9

The objective of this experiment was to understand changes in the properties and structure of materials that were exposed to the space environment and to compare these changes with predictions that were based on laboratory experiments.

***Figure 344 (Preflight).*** The experiment tray was divided into three sections. The right section provided space for the EPDS. The center section accommodated the SCU and an experiment mounting plate on an aluminum substructure, that was populated with composite material samples. The left section housed the EECC with a complement of experiment samples that consisted of coatings, thermal paints, polymers, glasses, and semiconductors. Detectors within the experiment provided environmental data for use in postflight analyses. The EPDS was underneath an aluminum cover, which was coated with a white thermal control paint (Chemglaze II A-276). The SCU cover was also coated with IITRI S13GLO white paint for thermal control. The EECC was covered with a chromic anodized aluminum thermal cover.

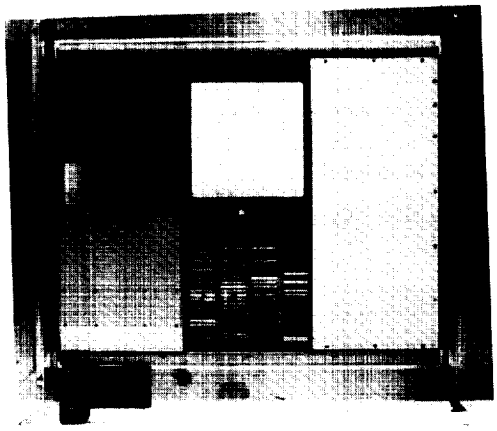

Figure 344
Photo No.: KSC-384C-193.08
Dup. Neg. No.: L84-7066
LISAR No.: EL-1994-00355
Photo Credit: KSC
Photo Date: 1/12/84
Location: KSC SAEF II
Subject: Preflight Survey of Tray D8

***Figure 345 (In Flight).*** The experiment hardware appears intact. The EPDS cover located in the right one-third of the tray has no apparent change in color, but the SCU cover located in the upper center one-sixth of the tray has a brownish tint with a darker tan strip along the lower line of screws. Colors of the composite material samples are bright and clear. Some material samples appear to be blue in this photograph, but they are not in prelaunch or post-flight photographs.

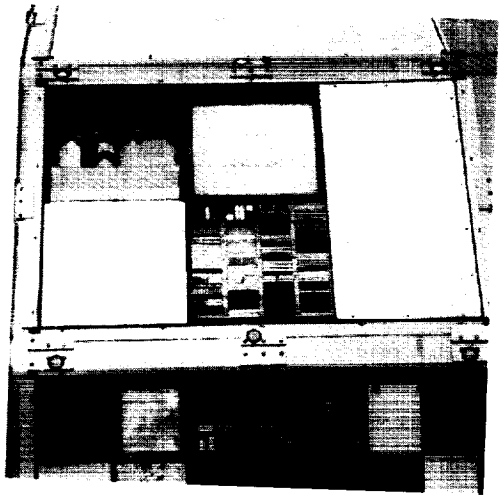

Figure 345
Photo No.: S32-76-013
Dup. Neg. No.: L90-10377
LISAR No.: EL-1994-00662
Photo Credit: JSC
Photo Date: 1/12/90
Location: In Flight
Subject: In-Flight Survey of Tray D8

***Figure 346 (Postflight).*** There seems to be no change from the in-flight appearance. All test specimens and hardware are intact. The EPDS cover, which was painted white, shows no apparent change in color, but the white paint on the SCU cover has a slight brownish tint. Some composite material samples are dull, some are discolored, and some are a different color from the preflight photograph. The bright square discolorations on the upper corners of the thermal cover are pads of tape that were used to cover sharp corners that were exposed. The pads were not in place in the prelaunch photograph.

Figure 346
Photo No.: KSC-390C-1031.09
Dup. Neg. No.: L90-13419
LISAR No.: EL-1994-00145
Photo Credit: KSC
Photo Date: 2/9/90
Location: KSC SAEF II
Subject: Postflight Survey of Tray D8

***Figure 347 (Postflight).*** This photograph is of the lower center one-sixth of the tray. Many of the test samples have changed color and have degraded finishes. The test specimen mounting hardware has numerous brown discolorations.

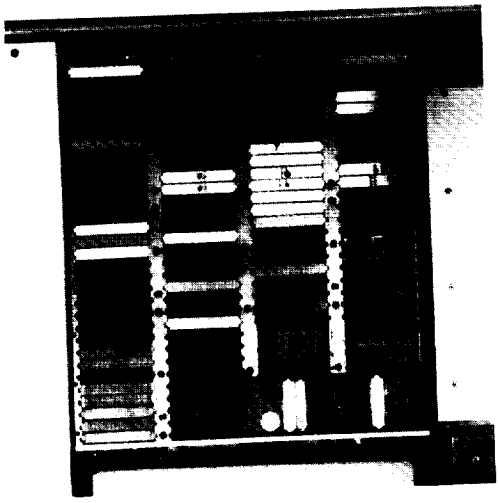

Figure 347
Photo No. KSC-390C-1534.12
Dup. Neg. No.: L91-10309
LISAR No.: EL-1994-00650
Photo Credit: KSC
Photo Date: 2/27/90
Location: KSC SAEF II
Subject: Postflight Detail of Lower Center of Tray D8

***Figure 348 (Postflight).*** This close-up photograph is of the upper left of the lower center one-sixth of the tray. Many of the test samples have changed color and have degraded finishes. The test specimen mounting hardware has numerous brown discolorations.

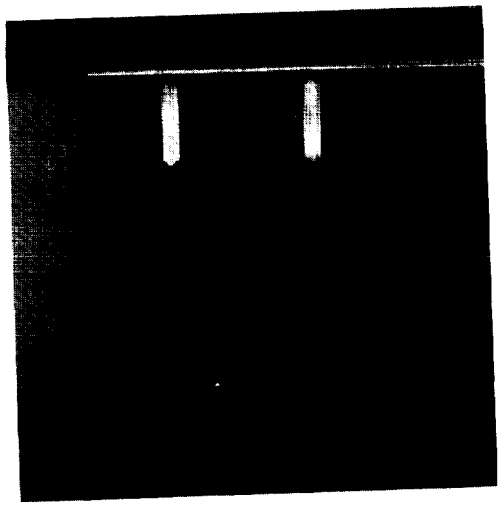

Figure 348
Photo No. KSC-390C-1535.02
Dup. Neg. No.: L91-10311
LISAR No.: EL-1994-00651
Photo Credit: KSC
Photo Date: 2/27/90
Location: KSC SAEF II
Subject: Postflight Detail of Upper Left of Lower Center of Tray D8

***Figure 349 (Postflight).*** This close-up photograph is of the upper right of the lower center one-sixth of the tray. Many test samples have changed color and have degraded finishes. The test specimen mounting hardware has numerous brown discolorations.

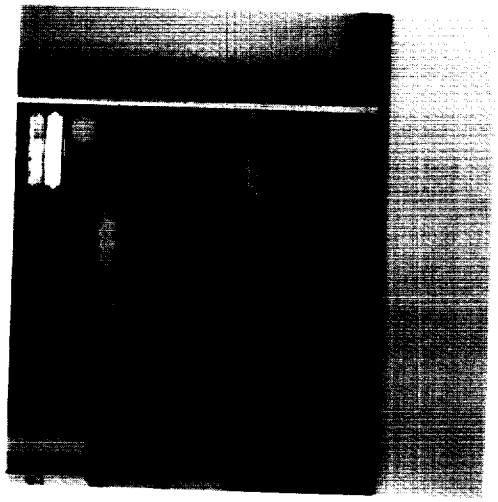

Figure 349
Photo No. KSC-390C-1535.04
Dup. Neg. No.: L91-10313
LISAR No.: EL-1994-00652
Photo Credit: KSC
Photo Date: 2/27/90
Location: KSC SAEF II
Subject: Postflight Detail of Upper Right of Lower Center of Tray D8

***Figure 350 (Postflight).*** This close-up photograph is of the lower left of the lower center one-sixth of the tray. Many test samples have changed color and have degraded finishes. The test specimen mounting hardware has numerous brown discolorations.

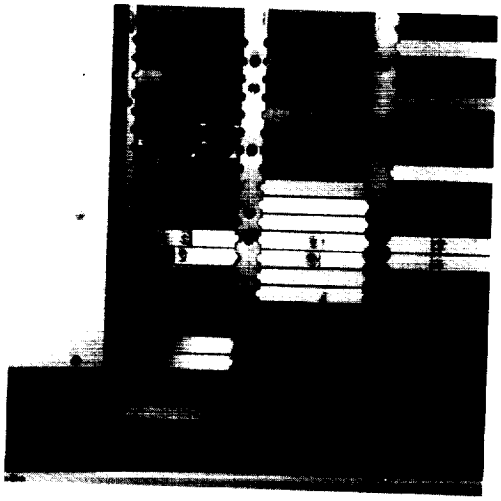

Figure 350
Photo No. KSC-390C-1535.06
Dup. Neg. No.: L91-10315
LISAR No.: EL-1994-00653
Photo Credit: KSC P
Photo Date: 2/27/90
Location: KSC SAEF II
Subject: Postflight Detail of Lower Left of Lower Center of Tray D8

***Figure 351 (Postflight).*** This close-up photograph is of the lower right of the lower center one-sixth of the tray. Many samples have changed color and have degraded finishes. The test specimen mounting hardware has numerous brown discolorations.

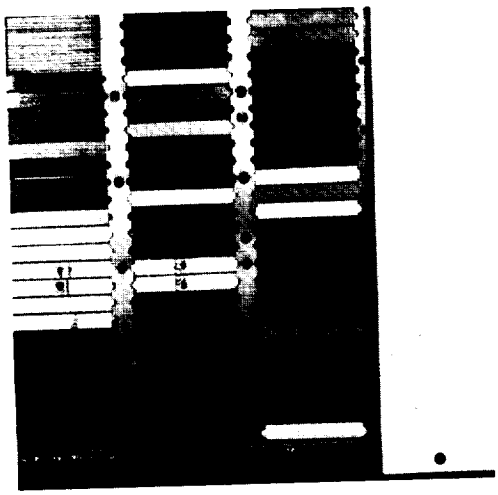

Figure 351
Photo No. KSC-390C-1535.08
Dup. Neg. No.: L91-10317
LISAR No.: EL-1994-00690
Photo Credit: KSC
Photo Date: 2/27/90
Location: KSC SAEF II
Subject: Postflight Detail of Lower Right of Lower Center of Tray D8

## Tray D9

Trapped Proton Energy Spectrum Determination (M0002-1)

Air Force Geophysics Laboratory

NASA MSFC

Army Materials and Mechanics Research Center

Clarkson College of Technology

Emmanuel College

Eastern Kentucky University

Trays: D3, D9, and G12

The objectives of this experiment were to measure the flux and the energy spectrum of protons with energies of 1 to 10 MeV.

Space Environment Effects on Spacecraft Materials (M0003)

The Aerospace Corporation

Trays: D3, D4, D8, and D9

The objective of this experiment was to understand changes in the properties and structure of materials that were exposed to the space environment and to compare these changes with predictions that were based on laboratory experiments.

***Figure 352 (Preflight).*** The experiment tray was divided into six sections. The lower right section contained experiment M0002-1. The other five sections of the tray contained experiment M0003, which consisted of coatings, thermal paints, polymers, glasses, composites, semiconductors, and detectors that provided data on environmental parameters.

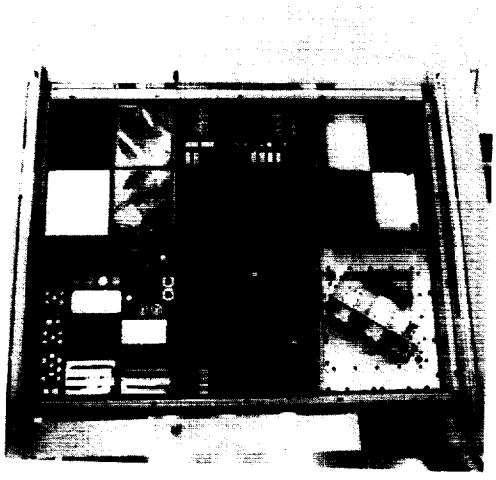

Figure 352
Photo No.: KSC-384C-8.02
Dup. Neg. No.: L84-6999
LISAR No.: EL-1994-00320
Photo Credit: KSC
Photo Date: 1/10/84
Location: KSC SAEF II
Subject: Preflight Survey of Tray D9

***Figure 353 (In Flight).*** The experiments located in the upper left and upper center sections are heavily coated with debris particles from other degraded experiments. Experiments in three of the five sections appear to have survived the mission with only minor physical damage. Experiments in the other two sections have sustained damage to thin metallized and coated polymer samples.

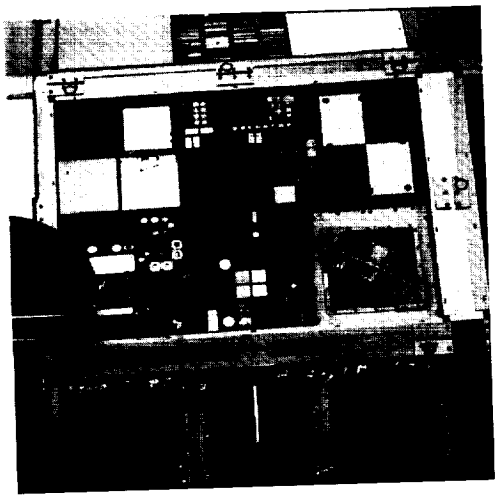

Figure 353
Photo No.: S32-78-093
Dup. Neg. No.: L90-10450
LISAR No.: EL-1994-00124
Photo Credit: JSC
Photo Date: 1/12/90
Location: In Flight
Subject: In-Flight Survey of Tray D9

***Figure 354 (Postflight).*** Experiments in three of the five sections appear to have survived the mission with minor physical damage. The experiments located in the upper left and upper center sections do not have the loose debris particles from the degradation of other experiments that were visible in the in-flight photograph. Experiments in the other two sections have sustained damage to thin metallized and coated polymer samples.

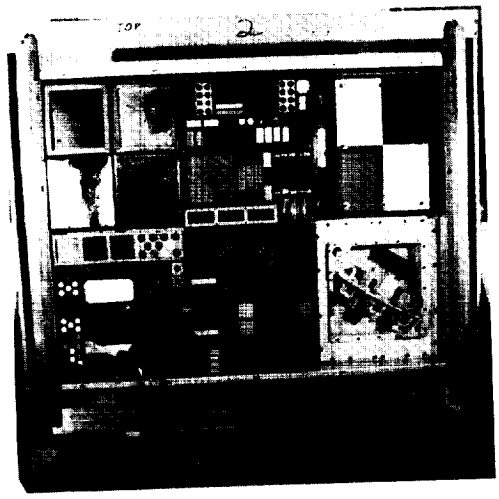

Figure 354
Photo No.: KSC-390C-1529.03
Dup. Neg. No.: L91-10336
LISAR No.: EL-1994-00211
Photo Credit: KSC
Photo Date: 2/27/90
Location: KSC SAEF II
Subject: Postflight Survey of Tray D9

***Figure 355 (Postflight).*** This photograph is of the upper left one-sixth of the tray. The thin film on the lower left corner is damaged. A shadow is visible on the upper right quadrant. A number of small impacts are visible.

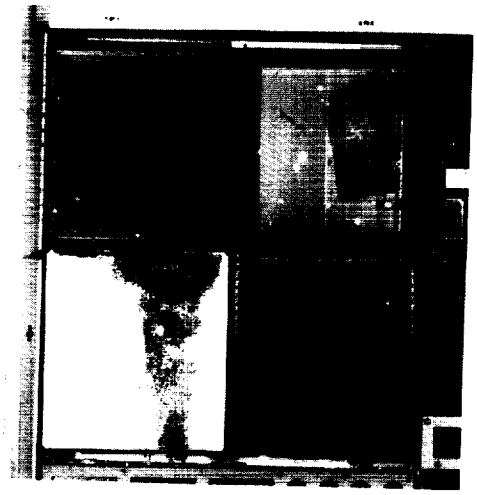

Figure 355
Photo No.: KSC-390C-1529.04
Dup. Neg. No.: L91-10337
LISAR No.: EL-1994-00095
Photo Credit: KSC
Photo Date: 2/27/90
Location: KSC SAEF II
Subject: Postflight Detail of Upper Left of Tray D9

***Figure 356 (Postflight).*** This photograph is of the upper center one-sixth of the tray. The test samples appear intact, but many are discolored.

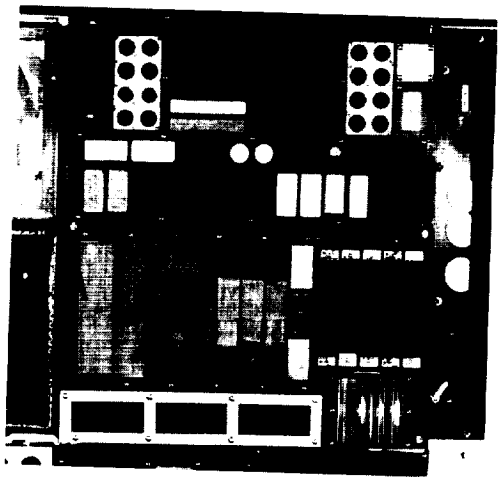

Figure 356
Photo No.: KSC-390C-1529.05
Dup. Neg. No.: L91-10338
LISAR No.: EL-1994-00324
Photo Credit: KSC
Photo Date: 2/27/90
Location: KSC SAEF II
Subject: Postflight Detail of Upper Center of Tray D9

***Figure 357 (Postflight).*** This photograph is of the upper right one-sixth of the tray. The test samples appear intact, but there seems to be some discoloration near the upper left corner of the baseplate.

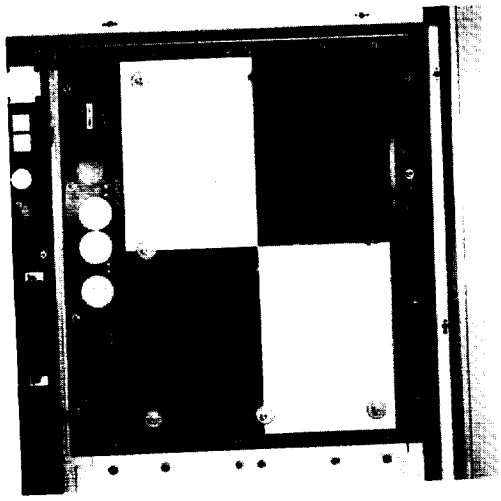

Figure 357
Photo No.: KSC-390C-1529.06
Dup. Neg. No.: L91-10339
LISAR No.: EL-1994-00096
Photo Credit: KSC
Photo Date: 2/27/90
Location: KSC SAEF II
Subject: Postflight Detail of Upper Right of Tray D9

***Figure 358 (Postflight).*** This photograph is of the lower left one-sixth of the tray. Many of the thin-film test specimens have broken and are attached by one end. Other test specimens appear intact, but some are discolored.

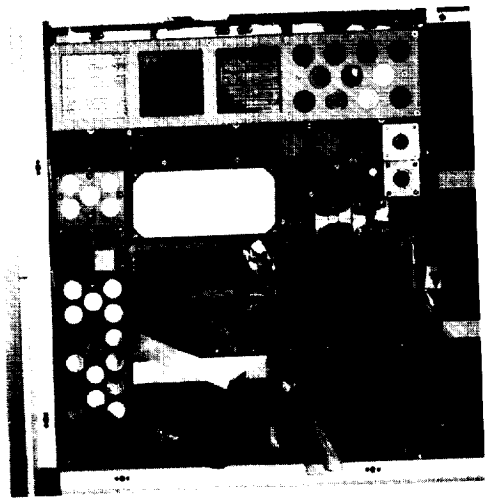

Figure 358
Photo No.: KSC-390C-1529.07
Dup. Neg. No.: L91-10340
LISAR No.: EL-1994-00097
Photo Credit: KSC
Photo Date: 2/27/90
Location: KSC SAEF II
Subject: Postflight Detail of Lower Left of Tray D9

***Figure 359 (Postflight).*** This photograph is of the lower center one-sixth of the tray. Loose ends of thin-film test samples are visible at the lower left corner. Other test specimens appear intact, but have some discoloration.

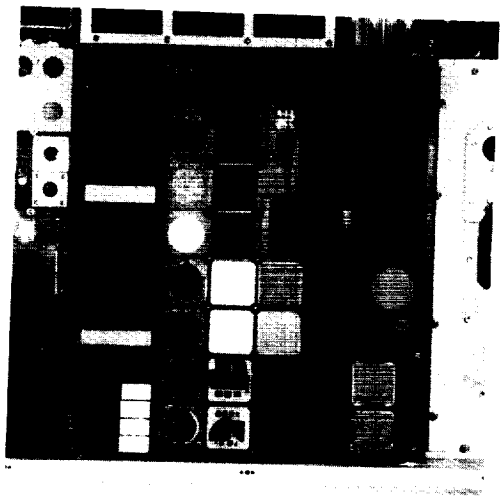

Figure 359
Photo No.: KSC-390C-1529.08
Dup. Neg. No.: L91-10341
LISAR No.: EL-1994-00649
Photo Credit: KSC
Photo Date: 2/27/90
Location: KSC SAEF II
Subject: Postflight Detail of Lower Center of Tray D9

***Figure 360 (Postflight).*** This photograph is of the lower right one-sixth of the tray. This experiment appears intact with some brown discoloration.

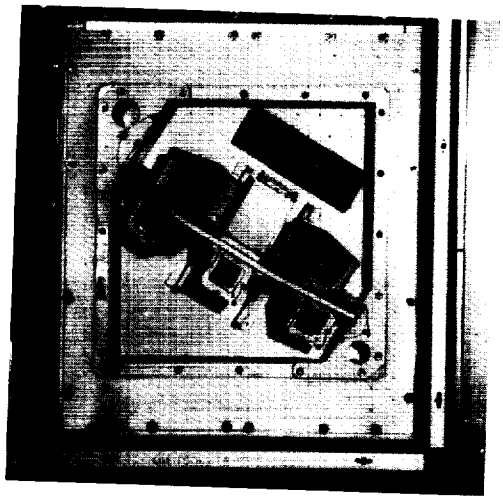

Figure 360
Photo No.: KSC-390C-1529.09
Dup. Neg. No.: L91-10342
LISAR No.: EL-1994-00649
Photo Credit: KSC
Photo Date: 2/27/90
Location: KSC SAEF II
Subject: Postflight Detail of Lower Right of Tray D9

## Tray D10

Space Plasma High-Voltage Drainage Experiment (SP HVD) (AO054)

TRW Space and Technology Group

Trays: B4 and D10

The objective of this experiment was to place large numbers of dielectric samples under electric stress in space to determine the long-term leakage of the dielectrics and the material degradation caused by both the low-Earth-orbit environment and the high-voltage systems.

***Figure 361 (Preflight).*** The experiment hardware is identical to that in tray B4 and shown in figure 158. Experiment AO054 consisted of two identical sets of hardware: one was mounted in tray B4 and the other was mounted in tray D10. Each set of hardware, which was self-contained within the experiment tray, consisted of six fiberglass-reinforced epoxy modules that carried charged dielectric samples on top and power supplies and electronics underneath. Four dielectric samples of Kapton film with vapor-deposited aluminum on one side (VDA-Kapton film) were bonded to each of the fiberglass modules with a silver-filled conductive epoxy adhesive. The spaces between the modules and between the modules and the tray flanges were covered by strips of VDA-Kapton film attached with acrylic transfer adhesive and Kapton tape. In this photograph, reflections in the mirrorlike surfaces are visible. Each experiment tray also contained two solar cell modules.

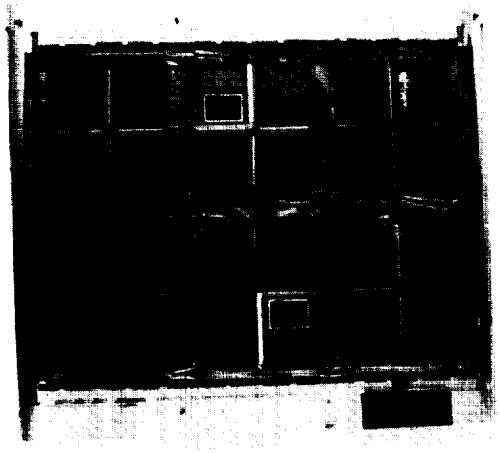

Figure 361
Photo No.: KSC-384C-193.07
Dup. Neg. No.: L84-7065
LISAR No.: EL-1994-00529
Photo Credit: KSC
Photo Date: 1/12/84
Location: KSC SAEF II
Subject: Preflight Survey of Tray D10

***Figure 362 (In Flight).*** The experiment is severely degraded. The most noticeable change is that the VDA-Kapton strips used to cover spaces between the modules have degraded substantially and only fragments of the layer of vapor-deposited aluminum remain attached along the edges. Other areas also show major degradation.

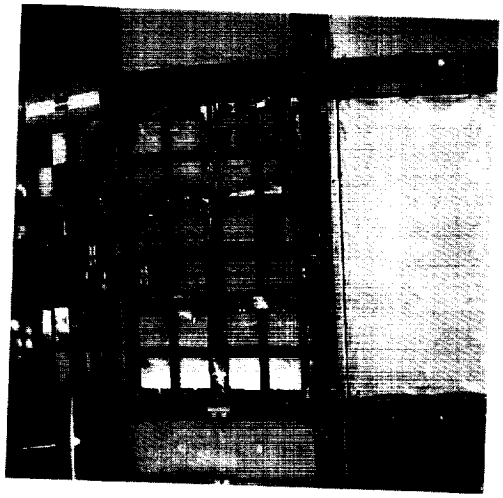

Figure 362
Photo No.: S32-78-062
Dup. Neg. No.: L90-10439
LISAR No.: EL-1994-00014
Photo Credit: JSC
Photo Date: 1/12/90
Location: In Flight
Subject: In-Flight Survey of Tray D10

***Figure 363 (Postflight).*** The experiment is severely degraded by impingement of atomic oxygen during exposure to the space environment. Most of the polyimide material making up the dielectric samples was completely eroded, thus leaving only the 2000 A to 3000 A layer of VDA bonded to the module.

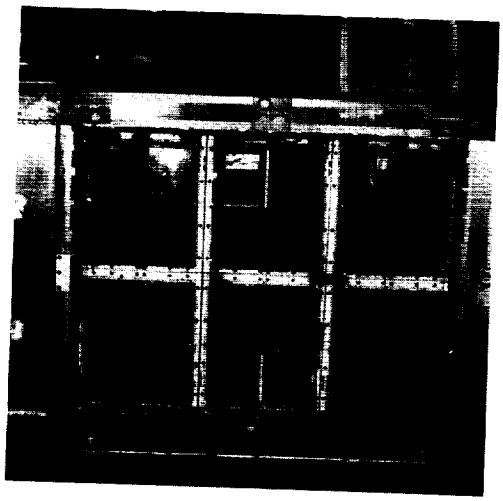

Figure 363
Photo No.: KSC-390C-1029.07
Dup. Neg. No.: L90-13393
LISAR No.: EL-1994-00142
Photo Credit: KSC
Photo Date: 2/9/90
Location: KSC SAEF II
Subject: Postflight Survey of Tray D10

***Figure 364 (Postflight).*** This photograph is of the upper left one-sixth of the tray. The polyimide material making up the dielectric samples was completely eroded, thus leaving only the 2000 A to 3000 A layer of VDA bonded to the module. The edges of the dielectric surface that survived were covered by Kapton tape with a silicone adhesive. The Kapton backing eroded, thus leaving the silicone adhesive that protected the Kapton surface beneath. The VDA-Kapton strips used to cover spaces between the modules were degraded substantially and only fragments of the extremely fragile VDA layer remain.

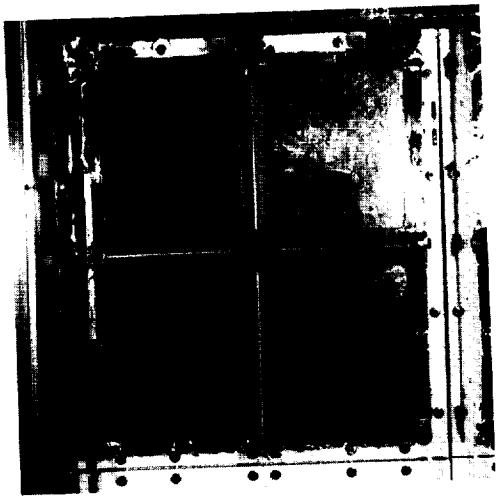

Figure 364
Photo No.: KSC-390C-1770.05
Dup. Neg. No.: L91-9107
LISAR No.: EL-1994-00222
Photo Credit: KSC
Photo Date: 3/9/90
Location: KSC SAEF II
Subject: Postflight Detail of Upper Left of Tray D10

***Figure 365 (Postflight).*** This photograph is of the upper center one-sixth of the tray. The polyimide material making up the dielectric samples was completely eroded, thus leaving only the 2000 A to 3000 A layer of VDA bonded to the module. The edges of the dielectric surface that survived were covered by Kapton tape with a silicone adhesive. The Kapton backing eroded, thus leaving the silicone adhesive that protected the Kapton surface beneath. The VDA-Kapton strips used to cover spaces between the modules were degraded substantially and only fragments of the extremely fragile VDA layer remain.

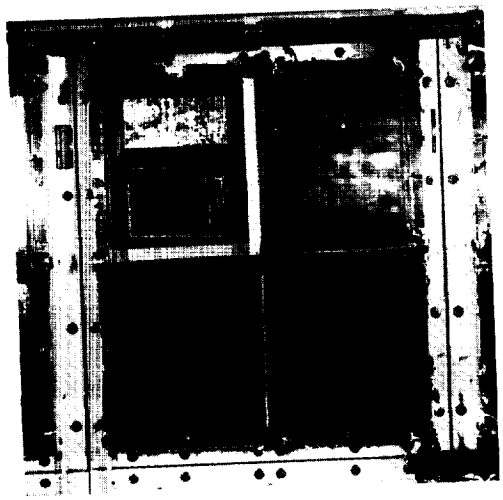

Figure 365
Photo No.: KSC-390C-1770.06
Dup. Neg. No.: L91-9108
LISAR No.: EL-1994-00223
Photo Credit: KSC
Photo Date: 3/9/90
Location: KSC SAEF II
Subject: Postflight Detail of Upper Center of Tray D10

***Figure 366 (Postflight).*** This photograph is of the upper right one-sixth of the tray. The polyimide material making up the dielectric samples was completely eroded, thus leaving only the 2000 A to 3000 A layer of VDA bonded to the module. The edges of the dielectric surface that survived were covered by Kapton tape with a silicone adhesive. The Kapton backing eroded, thus leaving the silicone adhesive that protected the Kapton surface beneath. The VDA-Kapton strips used to cover spaces between the modules were degraded substantially and only fragments of the extremely fragile VDA layer remain.

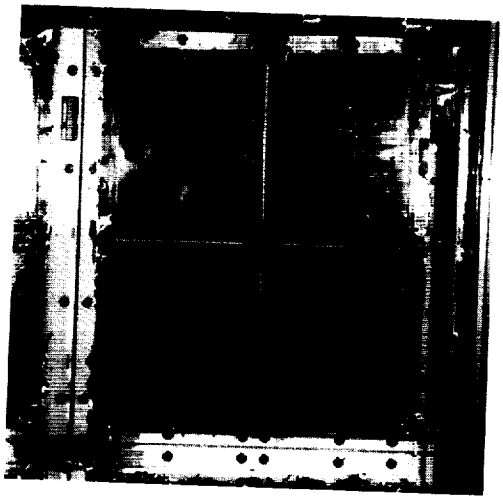

Figure 366
Photo No.: KSC-390C-1770.07
Dup. Neg. No.: L91-9109
LISAR No.: EL-1994-00224
Photo Credit: KSC
Photo Date: 3/9/90
Location: KSC SAEF II
Subject: Postflight Detail of Upper Right of Tray D10

***Figure 367 (Postflight).*** This photograph is of the lower left one-sixth of the tray. The polyimide material making up the dielectric samples was completely eroded, thus leaving only the 2000 A to 3000 A layer of VDA bonded to the module. The edges of the dielectric surface that survived were covered by Kapton tape with a silicone adhesive. The Kapton backing eroded, thus leaving the silicone adhesive that protected the Kapton surface beneath. The VDA-Kapton strips used to cover spaces between the modules were degraded substantially and only fragments of the extremely fragile VDA layer remain.

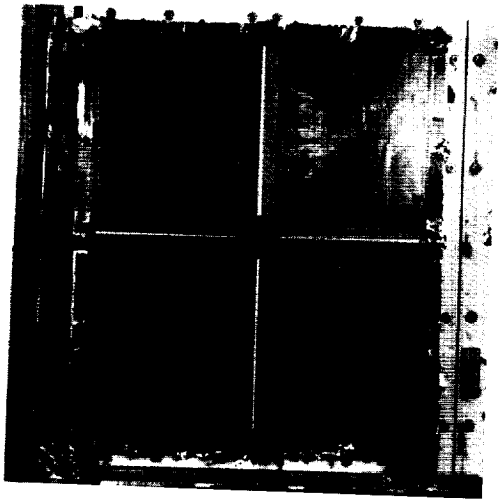

Figure 367
Photo No.: KSC-390C-1770.08
Dup. Neg. No.: L91-9110
LISAR No.: EL-1994-00225
Photo Credit: KSC
Photo Date: 3/9/90
Location: KSC SAEF II
Subject: Postflight Detail of Lower Left of Tray D10

***Figure 368 (Postflight).*** This photograph is of the lower center one-sixth of the tray. The polyimide material making up the dielectric samples was completely eroded, thus leaving only the 2000 A to 3000 A layer of VDA bonded to the module. The edges of the dielectric surface that survived were covered by Kapton tape with a silicone adhesive. The Kapton backing eroded, thus leaving the silicone adhesive that protected the Kapton surface beneath. The VDA-Kapton strips used to cover spaces between the modules were degraded substantially and only fragments of the extremely fragile VDA layer remain.

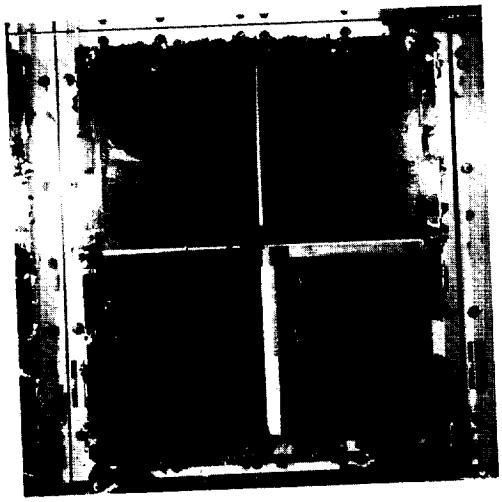

Figure 368
Photo No.: KSC-390C-1770.09
Dup. Neg. No.: L91-9111
LISAR No.: EL-1994-00226
Photo Credit: KSC
Photo Date: 3/9/90
Location: KSC SAEF II
Subject: Postflight Detail of Lower Center of Tray D10

***Figure 369 (Postflight).*** This photograph is of the lower right one-sixth of the tray. The polyimide material making up the dielectric samples was completely eroded, thus leaving only the 2000 A to 3000 A layer of VDA bonded to the module. The edges of the dielectric surface that survived were covered by Kapton tape with a silicone adhesive. The Kapton backing eroded, thus leaving the silicone adhesive that protected the Kapton surface beneath. The VDA-Kapton strips used to cover spaces between the modules were degraded substantially and only fragments of the extremely fragile VDA layer remain.

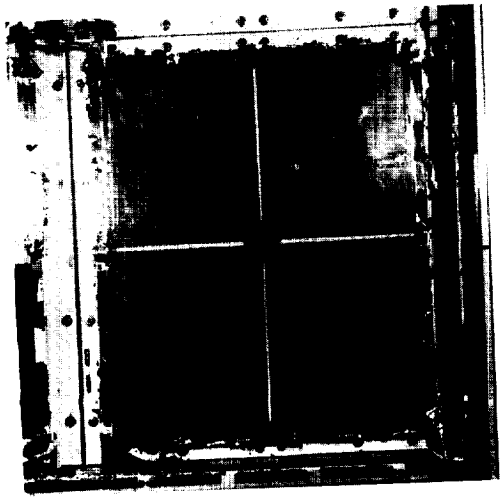

Figure 369
Photo No.: KSC-390C-1770.10
Dup. Neg. No.: L91-9112
LISAR No.: EL-1994-00227
Photo Credit: KSC
Photo Date: 3/9/90
Location: KSC SAEF II
Subject: Postflight Detail of Lower Right of Tray D10

***Figure 370 (Postflight).*** This photograph is of the upper left corner of the tray. The VDA-Kapton strips used to cover spaces between the modules have degraded substantially and only fragments of the extremely fragile VDA layer remain.

Figure 370
Photo No.: KSC-390C-1770.11
Dup. Neg. No.: L91-9113
LISAR No.: EL-1994-00392
Photo Credit: KSC
Photo Date: 3/9/90
Location: KSC SAEF II
Subject: Postflight Detail of Upper Left Corner of Tray D10

***Figure 371 (Postflight).*** This photograph is of the upper center edge of the tray. The VDA-Kapton strips used to cover spaces between the modules have degraded substantially and only fragments of the extremely fragile VDA layer remain.

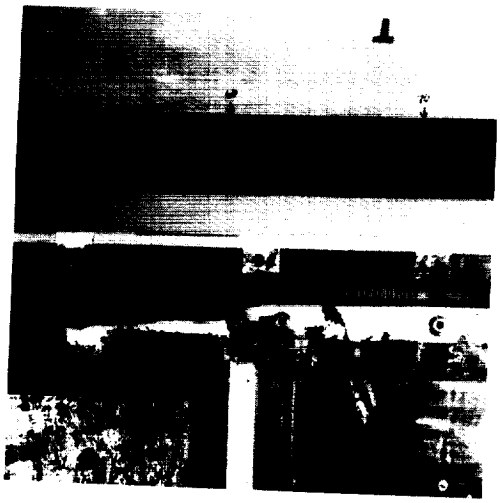

Figure 371
Photo No.: KSC-390C-1770.12
Dup. Neg. No.: L91-9114
LISAR No.: EL-1994-00393
Photo Credit: KSC
Photo Date: 3/9/90
Location: KSC SAEF II
Subject: Postflight Detail of Upper Center Edge of Tray D10

***Figure 372 (Postflight).*** This photograph is of the lower right corner of the tray. The VDA-Kapton strips used to cover spaces between the modules have degraded substantially and only fragments of the extremely fragile VDA layer remain.

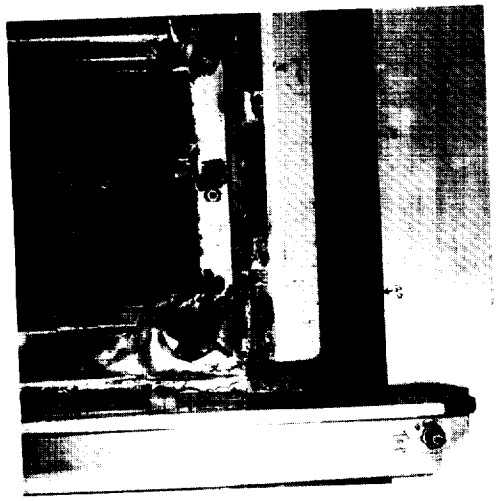

Figure 372
Photo No.: KSC-390C-1771.02
Dup. Neg. No.: L91-9116
LISAR No.: EL-1994-00394
Photo Credit: KSC
Photo Date: 3/9/90
Location: KSC SAEF II
Subject: Postflight Detail of Lower Right Corner of Tray D10

***Figure 373 (Postflight).*** This photograph is of the lower left corner of the tray. The VDA-Kapton strips used to cover spaces between the modules have degraded substantially and only fragments of the extremely fragile VDA layer remain.

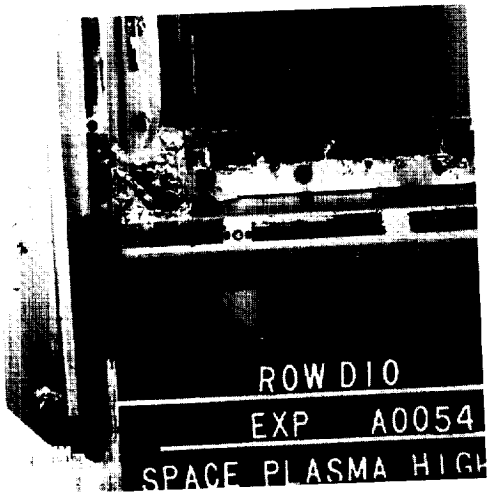


Figure 373
Photo No.: KSC-390C-1771.03
Dup. Neg. No.: L91-9117
LISAR No.: EL-1994-00395
Photo Credit: KSC
Photo Date: 3/9/90
Location: KSC SAEF II
Subject: Postflight Detail of Lower Left Corner of Tray D10

***Figure 374 (Postflight).*** This photograph is of the lower center edge of the tray. The VDA-Kapton strips used to cover spaces between the modules have degraded substantially and only fragments of the extremely fragile VDA layer remain.

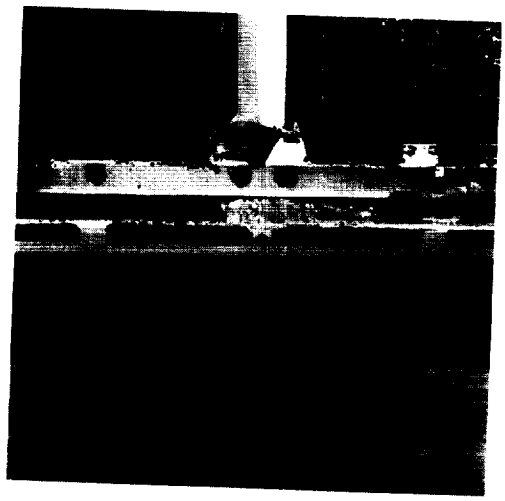

Figure 374
Photo No.: KSC-390C-1771.04
Dup. Neg. No.: L91-9118
LISAR No.: EL-1994-00396
Photo Credit: KSC
Photo Date: 3/9/90
Location: KSC SAEF II
Subject: Postflight Detail of Lower Center Edge of Tray D10

***Figure 375 (Postflight).*** This photograph is of the lower right corner of the tray. The VDA-Kapton strips used to cover spaces between the modules have degraded substantially and only fragments of the extremely fragile VDA layer remain.

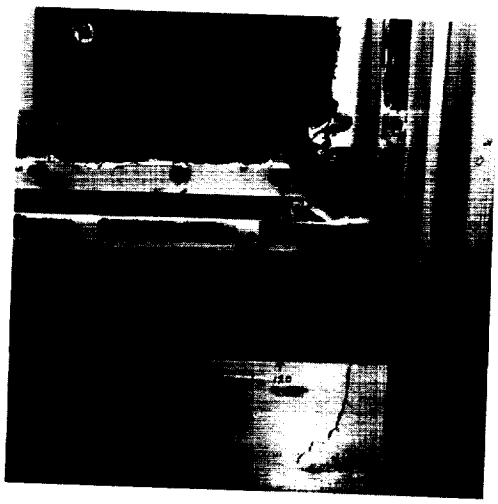

Figure 375
Photo No.: KSC-390C-1771.05
Dup. Neg. No.: L91-9119
LISAR No.: EL-1994-00397
Photo Credit: KSC
Photo Date: 3/9/90
Location: KSC SAEF II
Subject: Postflight Detail of Lower Right Corner of Tray D10

## Tray D11

A High-Resolution Study of Ultraheavy Cosmic Ray Nuclei (UHCRE) (AO178)

Dublin Institute for Advanced Studies

ESA at ESTEC

Trays: A2, A4, A10, B5, B7, C5, C6, C8, C11, D1, D5, D7, D11, E2, E10, and F4

See section entitled "Tray D5" and figure 319 for a typical preflight photograph of experiment AO178.

***Figure 376 (In Flight).*** The thermal cover surface has changed from specular to opaque with numerous black dots and dimples of various sizes that indicate space debris impacts or penetrations. There is an area of reflected light in the lower right area. The cover is taut and the locations of Velcro attachment pads are prominent. The ground strap appears to have no visible damage, but it appears to be a deeper copper color.

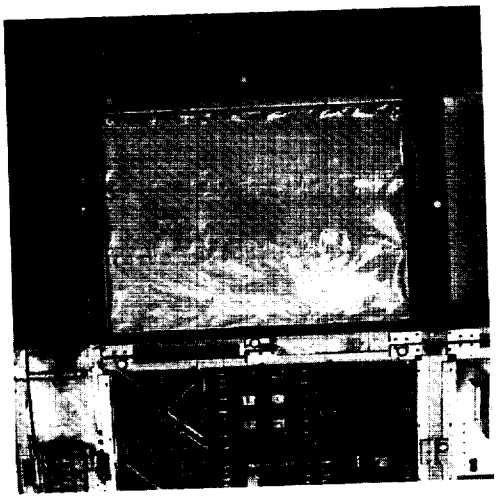

Figure 376
Photo No.: S32-78-047
Dup. Neg. No.: L90-10435
LISAR No.: EL-1994-00011
Photo Credit: JSC
Photo Date: 1/12/90
Location: In Flight
Subject: In-Flight Survey of Tray D11

***Figure 377 (Postflight).*** The thermal cover surface has changed from specular to opaque. Reflected light obscures some surface details. There are a number of small dark spots, which indicate impacts or penetrations. The cover is not as taut as in the in-flight photograph and locations of Velcro attachment pads are not as prominent. The ground strap appears to have no visible damage, but it appears to be a deeper copper color.

Figure 377
Photo No.: KSC-390C-1768.06
Dup. Neg. No.:L91-9382
LISAR No.: EL-1994-00277
Photo Credit: KSC
Photo Date: 3/9/90
Location: KSC SAEF II
Subject: Postflight Survey of Tray D11

***Figure 378 (Postflight).*** This photograph is of the upper left one-sixth of the tray. The thermal cover appears opaque, rather than specular as it was in preflight photographs. There are numerous discolored impacts or penetrations visible. The Velcro thermal cover attachment pads are evident.

Figure 378
Photo No.: KSC-390C-1768.07
Dup. Neg. No.: L91-9383
LISAR No.: EL-1994-00257
Photo Credit: KSC
Photo Date: 3/9/90
Location: KSC SAEF II
Subject: Postflight Detail of Upper Left of Tray D11

***Figure 379 (Postflight).*** This photograph is of the upper center one-sixth of the tray. The thermal cover appears opaque, rather than specular as it was in preflight photographs. There are numerous discolored impacts or penetrations visible. The Velcro thermal cover attachment pads are evident.

Figure 379
Photo No.: KSC-390C-1768.08
Dup. Neg. No.: L91-9384
LISAR No.: EL-1994-00258
Photo Credit: KSC
Photo Date: 3/9/90
Location: KSC SAEF II
Subject: Postflight Detail of Upper Center of Tray D11

***Figure 380 (Postflight).*** This photograph is of the upper right one-sixth of the tray. The thermal cover appears opaque, rather than specular as it was in preflight photographs. There are numerous discolored impacts or penetrations visible. The Velcro thermal cover attachment pads are evident.

Figure 380
Photo No.: KSC-390C-1768.09
Dup. Neg. No.: L91-9385
LISAR No.: EL-1994-00242
Photo Credit: KSC
Photo Date: 3/9/90
Location: KSC SAEF II
Subject: Postflight Detail of Upper Right of Tray D11

***Figure 381 (Postflight).*** This photograph is of the lower left one-sixth of the tray. The thermal cover appears opaque, rather than specular as it was in preflight photographs. There are numerous discolored impacts or penetrations visible. The Velcro thermal cover attachment pads are evident.

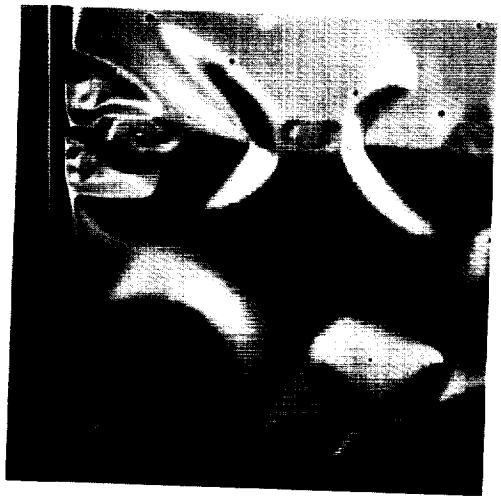

Figure 381
Photo No.: KSC-390C-1768.10
Dup. Neg. No.: L91-9386
LISAR No.: EL-1994-00219
Photo Credit: KSC
Photo Date: 3/9/90
Location: KSC SAEF II
Subject: Postflight Detail of Lower Left of Tray D11

***Figure 382 (Postflight).*** This photograph is of the lower center one-sixth of the tray. The thermal cover appears opaque, rather than specular as it was in preflight photographs. There are numerous discolored impacts or penetrations visible. The Velcro thermal cover attachment pads are evident.

Figure 382
Photo No.: KSC 390C-1768.11
Dup. Neg. No.: L91-9387
LISAR No.: EL-1994-00220
Photo Credit: KSC
Photo Date: 3/9/90
Location: KSC SAEF II
Subject: Postflight Detail of Lower Center of Tray D11

***Figure 383 (Postflight).*** This photograph is of the lower right one-sixth of the tray. The thermal cover appears opaque, rather than specular as it was in preflight photographs. There are numerous discolored impacts or penetrations visible. The Velcro thermal cover attachment pads are evident.

Figure 383
Photo No.: KSC-390C-1768.12
Dup. Neg. No.: L91-9388
LISAR No.: EL-1994-00221
Photo Credit: KSC
Photo Date: 3/9/90
Location: KSC SAEF II
Subject: Postflight Detail of Lower Right of Tray D11

## Tray D12

Influence of Extended Exposure in Space on Mechanical Properties of High-Toughness Graphite-Epoxy Composite Material (AO019)

University of Michigan

Tray: D12

The objective of this experiment was to test the effect of extended exposure to a space environment on the mechanical properties of a specially toughened T300/5208 graphite-epoxy composite material.

Multiple Foil Microabrasion Package (MAP) (AO023)

University of Kent

Trays: C3, C9, D12, E6, and H11

The objective of this experiment was to capture micrometeoroids and space debris particles with multiple thin aluminum and brass foil arrays, which ranged in thickness from 1.5 μm to 30 μm. This experiment looked for size, velocity, composition, and distribution of solid particles in the near-Earth environment.

The Effect of Space Environment Exposure on the Properties of Polymer Matrix Composite Materials (AO180)

University of Toronto

Tray: D12

The objective of this experiment was to determine the effect of various lengths of exposure to a space environment on the mechanical properties of selected commercial polymer matrix composite materials.

***Figure 384 (Preflight).*** Experiment AO019 consisted of six fracture toughness specimens and nine tensile module specimens that were located in the upper right one-sixth of the tray. Each specimen had a passive temperature indicator bonded to either the center edge or the end.

Experiment AO023, located in the left one-third tray section, is shown in figure 230.

Experiment AO180 is an active experiment that occupies half the exposed surface area of the tray and contains a data acquisition and recording system. The experiment consists of 62 composite tubes with aluminum end fittings, 45 flat composite coupons with aluminum retainer blocks, and 1 stainless steel calibration tube.

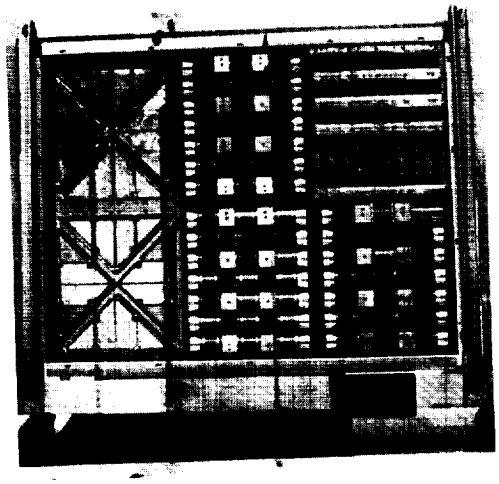

Figure 384
Photo No.: KSC-384C-221.11
Dup. Neg. No.: L84-7093
LISAR No.: EL-1994-00371
Photo Credit: KSC
Photo Date: 1/13/84
Location: KSC SAEF II
Subject: Preflight Survey of D12

***Figure 385 (In Flight).*** All experiment test specimens and hardware appear intact. Reflected sunlight caused uneven lighting of the frames of experiment AO023 and a white shape on the tray sidewall above the experiment detector stack. There is some change in the colors of the material of experiment AO180. Note the change in color of the tray clamp white dots across the photograph. The change from white to brown indicates the transition between leading and trailing sides.

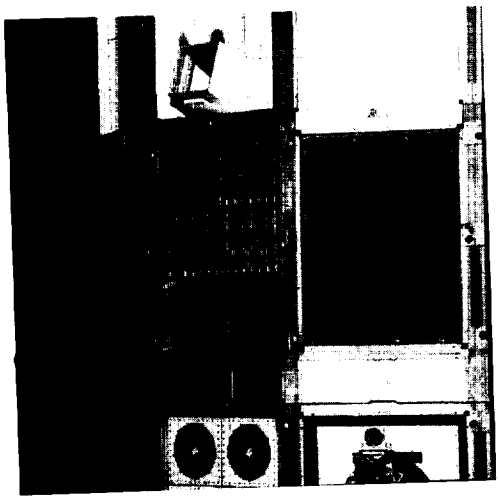

Figure 385
Photo No.: S32-89-052
Dup. Neg. No.: L90-10502
LISAR No.: EL-1994-00137
Photo Credit: JSC
Photo Date: 1/12/90
Location: In Flight
Subject: In-Flight Survey of Tray D12

***Figure 386 (Postflight).*** All experiment hardware remains intact. No change from inflight appearance is apparent. There are light reflections on many sensor surfaces.

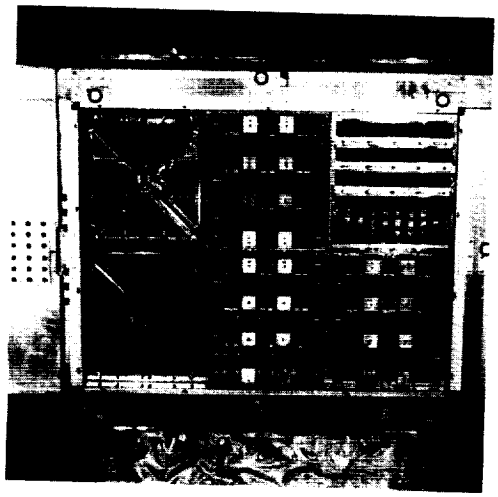

Figure 386
Photo No.: KSC-390C-1069.10
Dup. Neg. No.: L90-13490
LISAR No.: EL-1994-00203
Photo Credit: KSC
Photo Date: 2/8/90
Location: KSC SAEF II
Subject: Postflight Survey of Tray D5

***Figure 387 (Postflight).*** This photograph is of the upper left one-sixth of the tray. The sensor foils in the triangular quadrants are intact and some light reflects on the foil surfaces. There is some discoloration on the mounting frames.

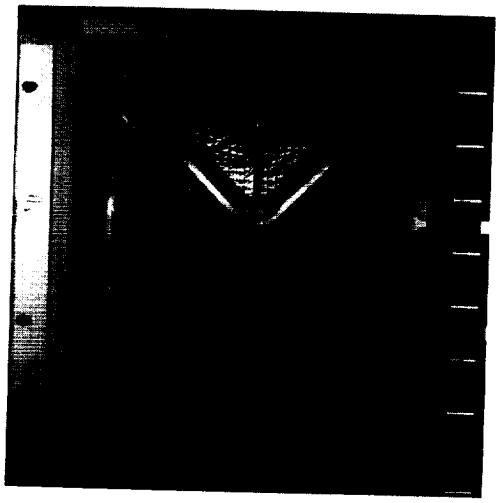

Figure 387
Photo No.: KSC-390C-2035.03
Dup. Neg. No.: L91-10379
LISAR No.: EL-1994-00456
Photo Credit: KSC
Photo Date: 3/16/90
Location: KSC SAEF II
Subject: Postflight Detail of Upper Left of Tray D12

***Figure 388 (Postflight).*** This photograph is of the upper center one-sixth of the tray. There is little change in the colors of the test specimens.

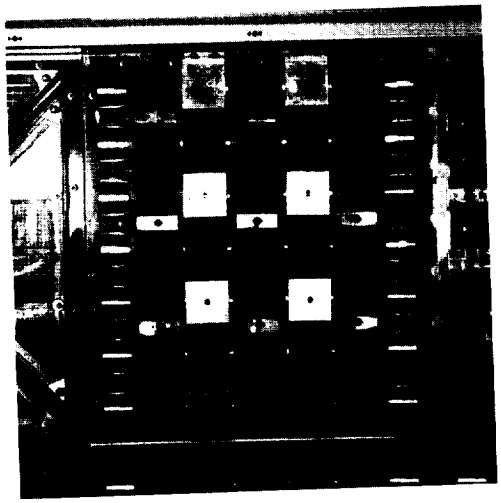

Figure 388
Photo No.: KSC-390C-2035.04
Dup. Neg. No.: L91-10380
LISAR No.: EL-1994-00457
Photo Credit: KSC
Photo Date: 3/16/90
Location: KSC SAEF II
Subject: Postflight Detail of Upper Center of Tray D12

***Figure 389 (Postflight).*** This photograph is of the upper right one-sixth of the tray. The test specimens are intact with no visible difference from preflight. The red passive temperature indicators remain bonded to the test specimens.

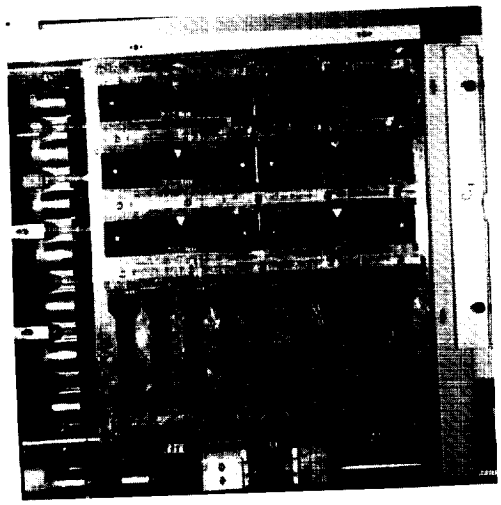

Figure 389
Photo No.: KSC-390C-2035.05
Dup. Neg. No.: L91-10381
LISAR No.: EL-1994-00458
Photo Credit: KSC
Photo Date: 3/16/90
Location: KSC SAEF II
Subject: Postflight Detail of Upper Right of Tray D12

***Figure 390 (Postflight).*** This photograph is of the lower left one-sixth of the tray. The sensor foils in the triangular quadrants are intact and some light reflects on the foils of the upper section. There is some discolorations along the foil and mounting frame line of the left and right quadrants.

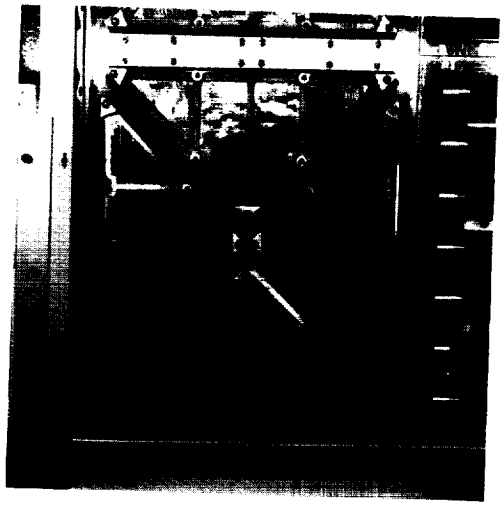

Figure 390
Photo No.: KSC-390C-2035.06
Dup. Neg. No.: L91-10382
LISAR No.: EL-1994-00459
Photo Credit: KSC
Photo Date: 3/16/90
Location: KSC SAEF II
Subject: Postflight Detail of Lower Left of Tray D12

***Figure 391 (Postflight).*** This photograph is of the lower center one-sixth of the tray. The test specimens are intact, but some are darker than in the preflight photograph.

Figure 391
Photo No.: KSC-390C-2035.07
Dup. Neg. No.: L91-10383
LISAR No.: EL-1994-00460
Photo Credit: KSC
Photo Date: 3/16/90
Location: KSC SAEF II
Subject: Postflight Detail of Lower Center of Tray D12

***Figure 392 (Postflight).*** This photograph is of the lower right one-sixth of the tray. The test specimens are intact, but some are darker than in the preflight photograph.

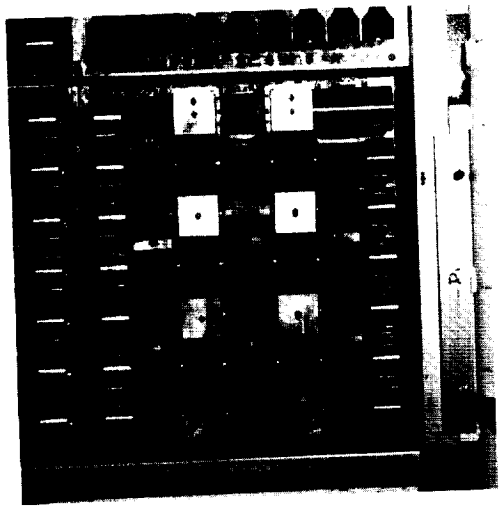

Figure 392
Photo No.: KSC-390C-2035.08
Dup. Neg. No.: L91-10384
LISAR No.: EL-1994-00461
Photo Credit: KSC
Photo Date: 3/16/90
Location: KSC SAEF II
Subject: Postflight Detail of Lower Right of Tray D12

## Tray E1

Space Debris Impact Experiment (S0001)

NASA LaRC

Trays: A5, A6, A12, B1, B2, B6, B8, B11, C4, C7, D2, D6, E1, E4, E7, E11, F1, F3, F5, F7, F10, F11, G4, G8, and H5

See section entitled "Tray A5" for a typical preflight photographic survey and experiment objective.

***Figure 393 (In Flight).*** The pink and greenish-gray tints on the two debris panels are by-products of the chromic anodize coating process and are not attributed to contamination or exposure to the space environment. The light color band across the top of the panels is a reflection from the tray sidewall.

Figure 393
Photo No.: S32-78-010
Dup. Neg. No.: L90-10426
LISAR No.: EL-1994-00003
Photo Credit: JSC
Photo Date: 1/12/90
Location: In Flight
Subject: In-Flight Survey of Tray E1

***Figure 394 (Postflight).*** The pink and greenish-gray tints on the two debris panels are by-products of the chromic anodize coating process and are not attributed to contamination or exposure to the space environment. The light band along the bottom of the panels is caused by light reflecting from the tray sidewalls.

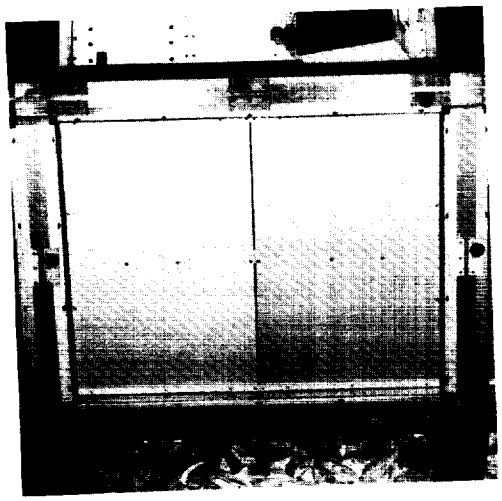

Figure 394
Photo No.: KSC-390C-1066.08
Dup. Neg. No.: L90-13477
LISAR No.: EL-1994-00187
Photo Credit: KSC
Photo Date: 2/8/90
Location: KSC SAEF II
Subject: Postflight Survey of Tray E1

## Tray E2

A High-Resolution Study of Ultraheavy Cosmic Ray Nuclei (UHCRE) (AO178)

Dublin Institute for Advanced Studies

ESA at ESTEC

Trays: A2, A4, A10, B5, B7, C5, C6, C8, C11, D1, D5, D7, D11, E2, E10, and F4

See section entitled "Tray D5" and figure 319 for a typical preflight photograph of experiment AO178.

***Figure 395 (In Flight).*** The thermal cover appears to be without visible damage, but it is more taut than in the prelaunch photograph. The Velcro attachment pads are evident. The grainy pattern in the surface finish, which is visible in the light reflection, was on the material prior to flight and is not from the space environment. The rippled effect around the cover edges occurs between the attachment pads.

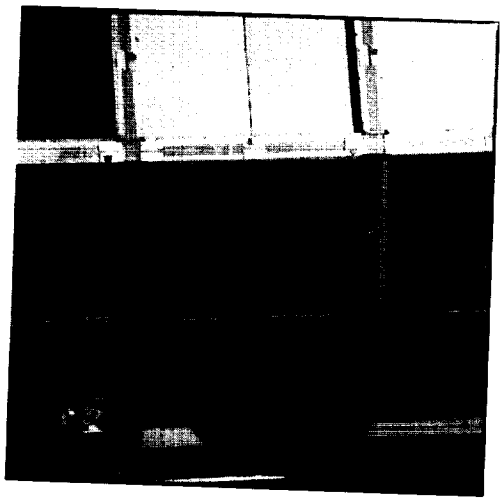

Figure 395
Photo No.: S32-89-018
Dup. Neg. No.: L90-10496
LISAR No.: EL-1994-00131
Photo Credit: JSC
Photo Date: 1/12/90
Location: In Flight
Subject: In-Flight Survey of Tray E2

***Figure 396 (Postflight).*** The thermal cover appears to be specular with no apparent damage. It is less taut than in the in-flight photograph. The Velcro attachment pads are more visible than in the prelaunch photograph. The scallop effect around the cover edges occurs between the attachment pads and shows the upper edge of the support frame. The ground strap is in place with no visible damage, but it is a darker color.

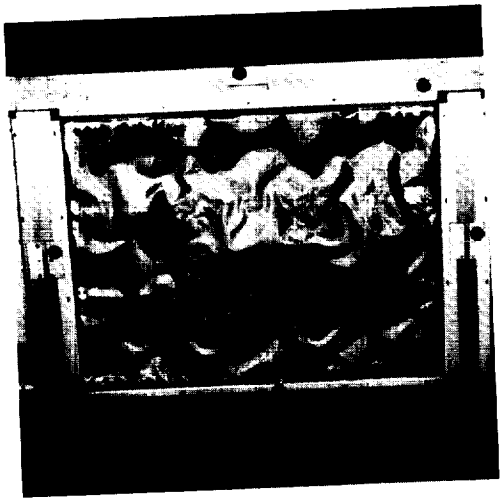

Figure 396
Photo No.: KSC-390C-1065.11
Dup. Neg.: L90-13468
LISAR No.: EL-1994-00385
Photo Credit: KSC
Photo Date: 2/8/90
Location: KSC SAEF II
Subject: Postflight Survey of Tray E2

***Figure 397 (Postflight).*** This photograph is of the upper left one-sixth of the tray. The thermal cover appears specular with no apparent damage. The reflective properties of the uneven surface of the cover result in various light and color patterns. The locations of the Velcro attachment pads are visible.

Figure 397
Photo No.: KSC-390C-2336.03
Dup. Neg. No.: L91-10423
LISAR No.: EL-1994-006026
Photo Credit: KSC
Photo Date: 3/27/90
Location: KSC SAEF II
Subject: Postflight Detail of Upper Left of Tray E2

***Figure 398 (Postflight).*** This photograph is of the upper center one-sixth of the tray. The thermal cover appears specular with no apparent damage. The reflective properties of the uneven surface of the cover result in various light and color patterns. The locations of the Velcro attachment pads are visible.

Figure 398
Photo No.: KSC-390C-2336.04
Dup. Neg. No.: L91-10424
LISAR No.: EL-1994-00603
Photo Credit: KSC
Photo Date: 3/27/90
Location: KSC SAEF II
Subject: Postflight Detail of Upper Center of Tray E2

***Figure 399 (Postflight).*** This photograph is of the upper right one-sixth of the tray. The grainy pattern in the surface finish, which is visible in the light reflection, was on the material prior to flight. The thermal cover appears specular with no apparent damage. The reflective properties of the uneven surface of the cover result in various light and color patterns. The locations of the Velcro attachment pads are visible.

Figure 399
Photo No.: KSC-390C-2336.05
Dup. Neg. No.: L91-10425
LISAR No.: EL-1994-00604
Photo Credit: KSC
Photo Date: 3/27/90
Location: KSC SAEF II
Subject: Postflight Detail of Upper Right of Tray E2

***Figure 400 (Postflight).*** This photograph is of the lower left one-sixth of the tray. The thermal cover appears specular with no apparent damage. The reflective properties of the uneven surface of the cover result in various light and color patterns. The locations of the Velcro attachment pads are visible.

Figure 400
Photo No.: KSC-390C-2336.09
Dup. Neg. No.: L91-10429
LISAR No.: EL-1994-00605
Photo Credit: KSC
Photo Date: 3/27/90
Location: KSC SAEF II
Subject: Postflight Detail of Lower Left of Tray E2

***Figure 401 (Postflight).*** This photograph is of the lower center one-sixth of the tray. The thermal cover appears specular with no apparent damage. The reflective properties of the uneven surface of the cover result in various light and color patterns. The locations of the Velcro attachment pads are visible.

Figure 401
Photo No.: KSC-390C-2336.10
Dup. Neg. No.: L91-10430
LISAR No.: EL-1994-00617
Photo Credit: KSC
Photo Date: 3/27/90
Location: KSC SAEF II
Subject: Postflight Detail of Lower Center of Tray E2

***Figure 402 (Postflight).*** This photograph is of the lower right one-sixth of the tray. The grainy pattern in the surface finish, which is visible in the light reflection, was on the material prior to flight. The thermal cover appears specular with no apparent damage. The reflective properties of the uneven surface of the cover result in various light and color patterns. The locations of the Velcro attachment pads are visible.

Figure 402
Photo No.: KSC-390C-2336.11
Dup. Neg. No.: L91-10431
LISAR No.: EL-1994-00621
Photo Credit: KSC
Photo Date: 3/27/90
Location: KSC SAEF II
Subject: Postflight Detail of Lower Right of Tray E2

## Tray E3

Chemical and Isotopic Measurements of Micrometeoroids by Secondary Ion Mass Spectrometry (AO187-2)

McDonnell Center for the Space Sciences

Max-Planck Institute for Nuclear Physics

Munich Technical University

Ernst-Mach Institute

Dornier System Manufacturing Company

Trays: C2, E3, and E8

The objective of this experiment was to measure the chemical and the isotopic composition of interplanetary dust particles.

Investigation of Critical Surface Degradation Effects on Coatings and Solar Cells Developed in Germany (S1002)

Space Division, Messerschmitt-Bolkow-Blohm

Tray: E3

The objective of this experiment was to qualify various coatings under realistic space environment conditions. In addition, the experiment provided design criteria, techniques, and test methods to ensure control of the combined space and spacecraft environmental effects.

***Figure 403 (Preflight).*** This photograph shows experiment AO187-2 in the right two-thirds of the tray and the EECC that contained experiment S1002 in the left one-third. The tan strips on the tray flanges are protective coatings that were removed prior to tray testing. Each of the 77 capture cells of experiment AO187-2 consisted of four highly polished germanium plates. These plates were covered with a 2.5-μm thick Mylar foil with 1300 A of tantalum vapor that was deposited on the back and 100 A of gold-palladium that was vapor deposited on the front. Two calorimeters are shown mounted in the top center and lower center of the experiment panel. An aluminum cover in the upper right section of the panel protected electrical connections. Reflections of both personnel and equipment are visible in the metallic-coated Mylar foil that covers the germanium detector plates.

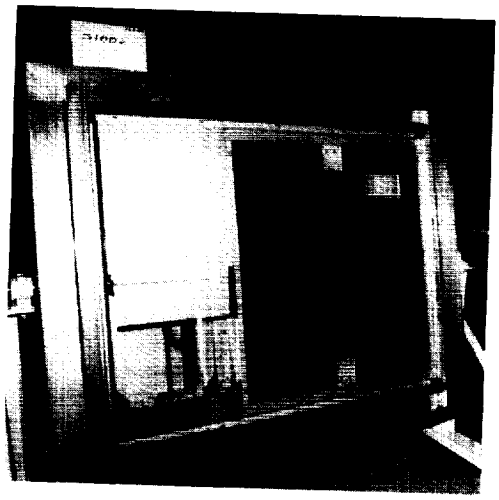

Figure 403
Photo No.: KSC-383C-4209.06
Dup. Neg. No.: L84-7293
LISAR No.: EL-1994-00301
Photo Credit: KSC
Photo Date: 12/1/83
Location: KSC SAEF II
Subject: Preflight Survey of Tray E3

***Figure 404 (In Flight).*** The capture cells appear to be severely damaged. Fragments of the failed capture cell covers, which have curled into tight conical shapes, are attached to edges of the aluminum mounting frame. The capture cell mounting structure and calorimeter mounting plates are discolored; some areas have more pronounced discoloration than others. The canister for experiment S1002 is closed.

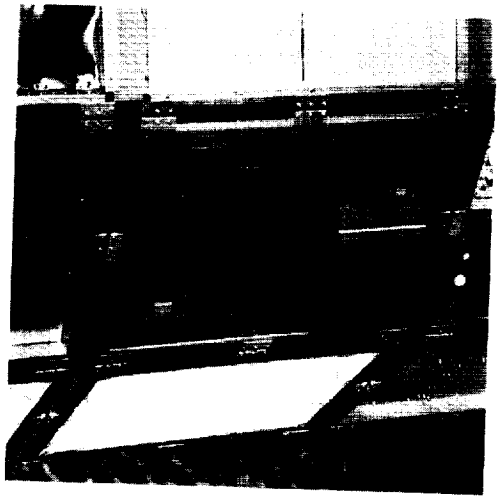

Figure 404
Photo No.: S32-77-067
Dup. Neg. No.: L90-10417
LISAR No.: EL-1994-00001
Photo Credit: JSC
Photo Date: 1/12/90
Location: KSC SAEF II
Subject: In-Flight Survey of Tray E3

***Figure 405 (Postflight).*** The capture cells have degraded and only 11 of the 77 metallized Mylar covers survived. There is a brown stain on the tray, the capture cell mounting, and the calorimeter mounting plates. The green tint on the right side of the experiment is a reflection of lights from an adjacent room. The canister for experiment S1002 is closed.

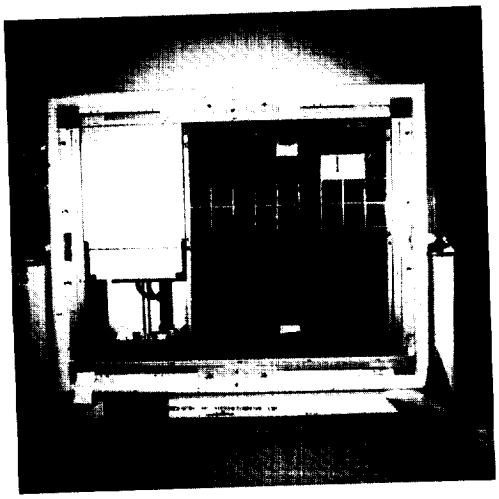

Figure 405
Photo No.: KSC-390C-1839.02
Dup. Neg. No.: L91-10443
LISAR No.: EL-1994-00278
Photo Credit: KSC
Photo Date: 3/12/90
Location: KSC SAEF II
Subject: Postflight Survey of Tray E3

***Figure 406 (Postflight).*** This photograph is of the upper left one-fourth of experiment AO187-2. Two capture cell covers are intact. The remains of the others are curled tightly and hanging from one edge. There is considerable discoloration on the upper mounting frame and on the calorimeter.

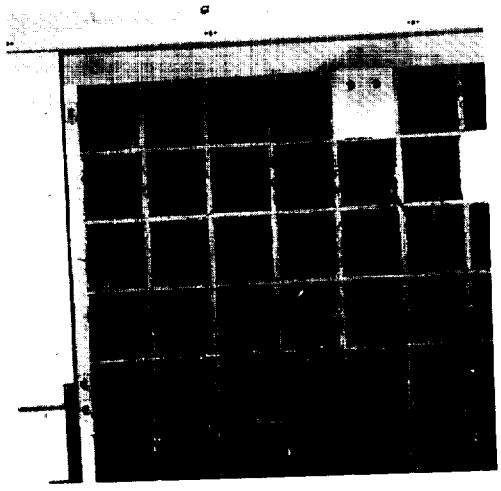

Figure 406
Photo No.: KSC-390C-1839.04
Dup. Neg. No.: L91-10445
LISAR No.: EL-1994-00404
Photo Credit: KSC
Photo Date: 3/12/90
Location: KSC SAEF II
Subject: Postflight Detail of Upper Left of Tray E3

***Figure 407 (Postflight).*** This photograph is of the upper right one-fourth of experiment AO187-2. Three capture cell covers are intact. The remains of the others are curled tightly and are hanging from one edge. There is considerable discoloration on the upper and right sides of the mounting frame and on the calorimeter.

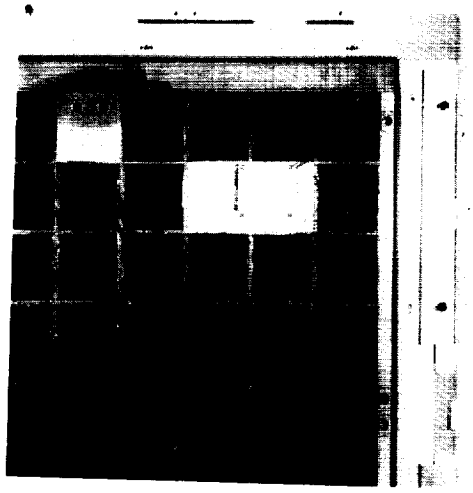

Figure 407
Photo No.: KSC-390C-1839.05
Dup. Neg. No.: L91-10446
LISAR No.: EL-1994-00405
Photo Credit: KSC
Photo Date: 3/12/90
Location: KSC SAEF II
Subject: Postflight Detail of Upper Right of Tray E3

***Figure 408 (Postflight).*** This photograph is of the lower left one-fourth of experiment AO187-2. Four capture cell covers are intact. The remains of the others are curled tightly and are hanging from one edge. There is considerable discoloration on the left and lower sides of the mounting frame and on the calorimeter. Note the reflection of the photographer.

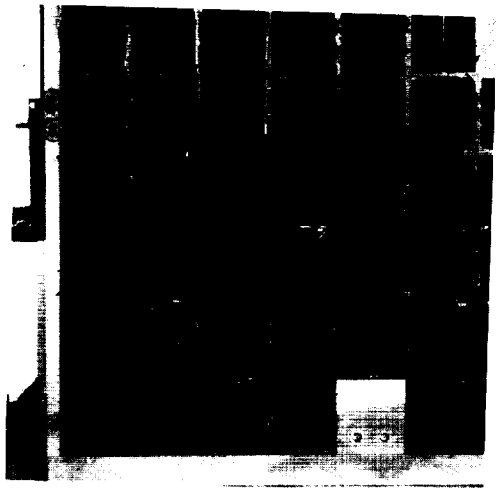

Figure 408
Photo No.: KSC-390C-1839.07
Dup. Neg. No.: L91-10448
LISAR No.: EL-1994-00406
Photo Credit: KSC
Photo Date: 3/12/90
Location: KSC SAEF II
Subject: Postflight Detail of Lower Left of Tray E3

***Figure 409 (Postflight).*** This photograph is of the lower right one-fourth of experiment AO187-2. Four capture cell covers are intact. The remains of the others are curled tightly and are hanging from one edge. There is considerable discoloration on the lower and right sides of the mounting frame and on the calorimeter. Note the reflection of the photographer.

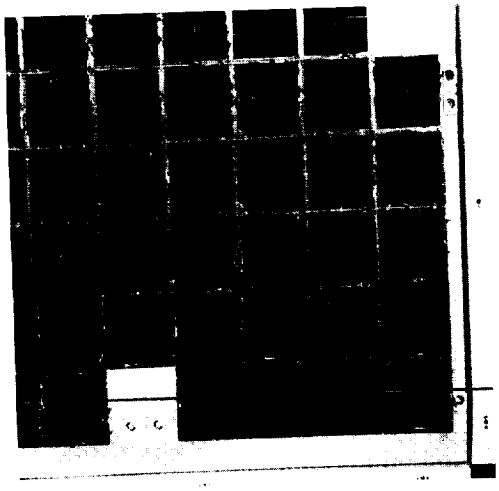

Figure 409
Photo No.: KSC-390C-1839.08
Dup. Neg. No.: L91-10449
LISAR No.: EL-1994-00407
Photo Credit: KSC
Photo Date: 3/12/90
Location: KSC SAEF II
Subject: Postflight Detail of Lower Right of Tray E3

## Tray E4

Space Debris Impact Experiment (S0001)

NASA LaRC

Trays: A5, A6, A12, B1, B2, B6, B8, B11, C4, C7, D2, D6, E1, E4, E7, E11, F1, F3, F5, F7, F10, F11, G4, G8, and H5

See section entitled "Tray A5" for a typical preflight photographic survey and experiment objective.

***Figure 410 (In Flight).*** The greenish-gray and pink tints on the two debris panels are by-products of the chromic anodize coating process and are not attributed to contamination or exposure to the space environment. Discolorations are visible along some edges of the panels, thus indicating improper handling and cleaning after panel assembly.

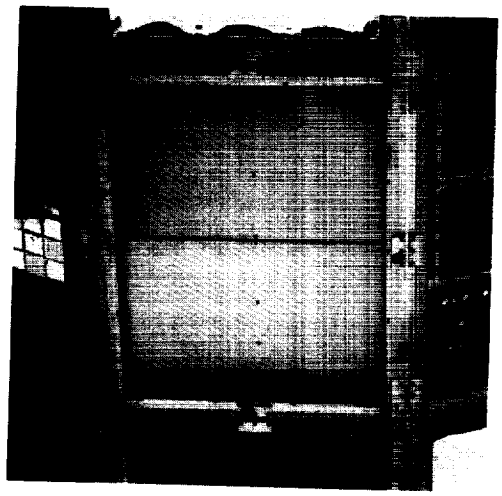

Figure 410
Photo No.: S32-77-048
Dup. Neg. No.: L90-10412
LISAR No.: EL-1994-00678
Photo Credit: JSC
Photo Date: 1/12/90
Location: KSC SAEF II
Subject: In-Flight Survey of Tray E4

***Figure 411 (Postflight).*** The greenish-gray and pink tints on the two debris panels are by-products of the chromic anodize coating process and are not attributed to contamination or exposure to the space environment. The fingerprints along the bottom edge of the panels that were observed in the in-flight photograph are still visible.The light band along the sides and across the bottom of the tray is caused by light reflected from the tray sidewalls.

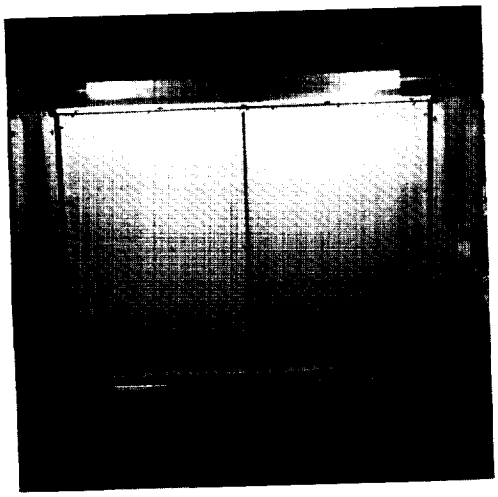

Figure 411
Photo No.: KSC-390C-832.03
Dup. Neg. No.: L90-13350
LISAR No.: EL-1994-00172
Photo Credit: KSC
Photo Date: 2/7/90
Location: KSC SAEF II
Subject: Postflight Survey of Tray E4

## Tray E5

Holographic Data Storage Crystals for LDEF (AO044)

Georgia Institute of Technology

Tray: E5

The objective of this passive experiment was to test the space worthiness of electro-optic crystals for use in ultrahigh-capacity space data storage and retrieval systems.

Effect of Space Exposure on Pyroelectric Infrared Detectors (AO135)

NASA LaRC

Tray: E5

The objective of this experiment was to determine the effects of long-term space exposure on pyroelectric infrared detectors that are useful in the wavelength range of 1 μm to 100 μm.

Investigation of the Effects of Long Duration Exposure of Active Optical System Components (S0050)

Georgia Institute of Technology

Tray: E5

Investigation of the Effects of Long Duration Exposure on Active Optical Materials and UV Detectors (S0050-1)

NASA LaRC

Tray: E5

Optical Substrates and Coatings Experiment (S0050-2)

NASA LaRC

Tray: E5

The objectives of these experiments were to determine quantitatively the effects of long duration space exposure on the relevant performance parameters of lasers, radiation detectors, and selected optical components.

***Figure 412 (Preflight).*** The test specimens were typically placed on fiberglass-epoxy retainer strip assemblies and mounted in the tray. Five of the six sections of the tray were covered by a 1/8-in-thick anodized aluminum sun screen with openings that allowed 56-percent transmission over the central region. The remaining one-sixth was open to the space environment.

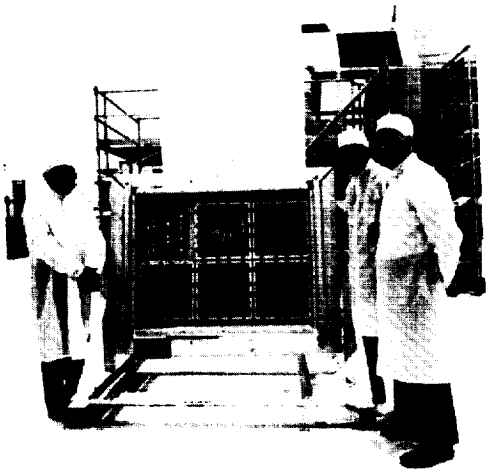

Figure 412
Photo No.: KSC-384C-255.06
Dup. Neg. No.: L89-4387
LISAR No.: EL-1994-00372
Photo Credit: KSC
Photo Date: 1/18/90
Location: KSC SAEF II
Subject: Preflight Survey of Tray E5

***Figure 413 (In Flight).*** In this photograph, the experiment hardware appears to be without physical damage. The blue is due to lighting. The exposed experiment test specimens and the fiberglass-epoxy mountings appear to have survived the mission. The colors of the fiberglass-epoxy mounting strip have changed from the typical greenish gray to a slate gray and the colors of the test specimen appear to be much darker than in the prelaunch photograph.

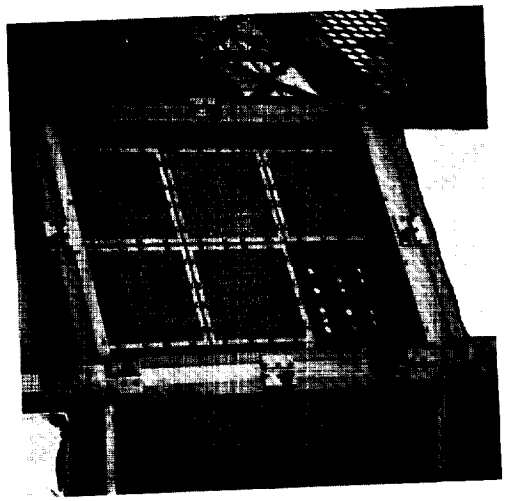

Figure 413
Photo No.: S32-77-050
Dup. Neg. No.: L90-10413
LISAR No.: EL-1994-00679
Photo Credit: JSC
Photo Date: 1/12/90
Location: KSC SAEF II
Subject: In-Flight Survey of Tray E5

***Figure 414 (Postflight).*** The experiment hardware appears to be without physical damage.

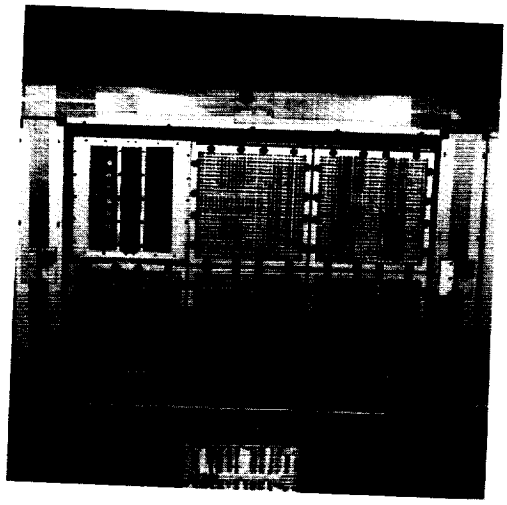

Figure 414
Photo No.: KSC-390C-1035.05
Dup. Neg. No.: L90-13450
LISAR No.: EL-1994-00183
Photo Credit: KSC
Photo Date: 2/9/90
Location: KSC SAEF II
Subject: Postflight Survey of Tray E5

***Figure 415 (Postflight).*** This photograph was taken after the experiment tray was removed from the LDEF and the sun screens were removed. The experiment hardware appears to be without physical damage. The colors of the fiberglass-epoxy mounting strip vary from the typical greenish gray to a slate gray in proportion to their exposure. The red material on top of the aluminum support structure are silicon rubber gaskets between the sun screen and the structure. The gasket material that is missing adhered to the sun screens.

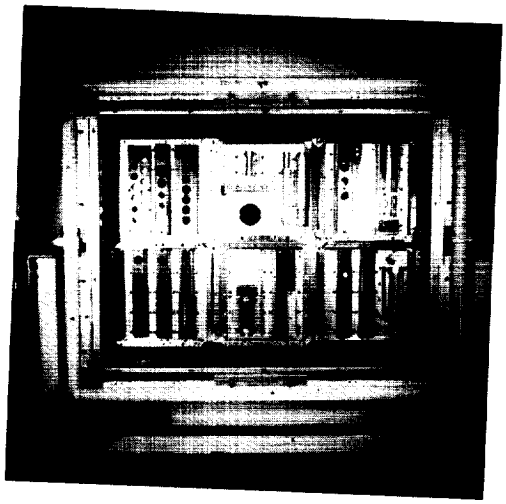

Figure 415
Photo No.: KSC-390C-2114.03
Dup. Neg. No.: L91-10508
LISAR No.: EL-1994-00491
Photo Credit: KSC
Photo Date: 3/20/90
Location: KSC SAEF II
Subject: Postflight Survey of Tray E5

***Figure 416 (Postflight).*** This photograph is of the upper center one-sixth of the tray. The experiment hardware is without physical damage.

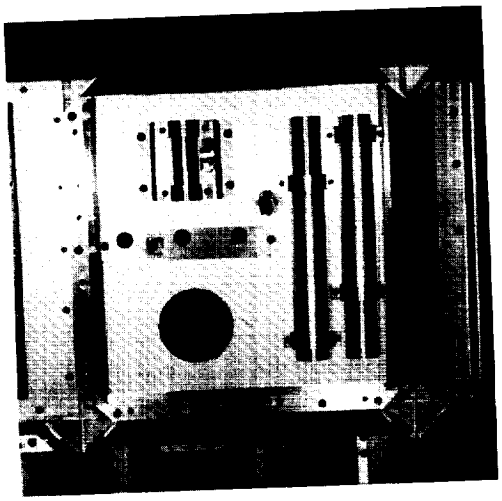

Figure 416
Photo No.: KSC-390C-2114.04
Dup. Neg. No.: L91-10509
LISAR No.: EL-1994-00492
Photo Credit: KSC
Photo Date: 3/20/90
Location: KSC SAEF II
Subject: Postflight Detail of Upper Center of Tray E5

***Figure 417 (Postflight).*** This photograph is of the upper right one-sixth of the tray. The experiment hardware is without physical damage.

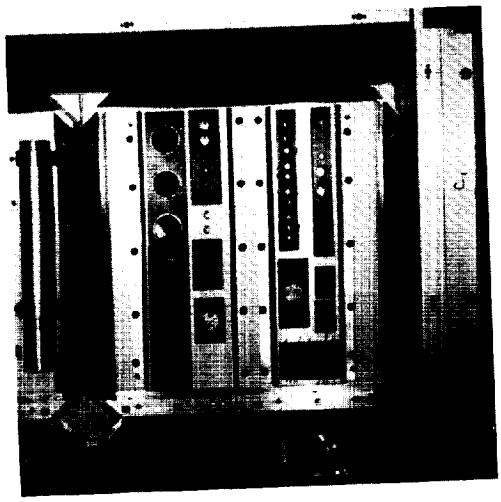

Figure 417
Photo No.: KSC-390C-2114.05
Dup. Neg. No.: L91-10510
LISAR No.: EL-1994-00493
Photo Credit: KSC
Photo Date: 3/20/90
Location: KSC SAEF II
Subject: Postflight Detail of Upper Right of Tray E5

***Figure 418 (Postflight).*** This photograph is of the lower left one-sixth of the tray. The experiment hardware is without physical damage.

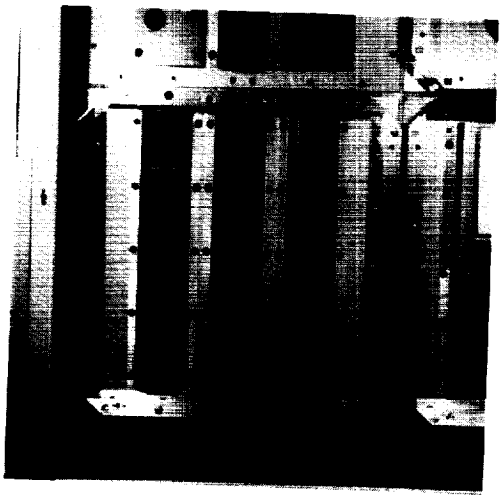

Figure 418
Photo No.: KSC-390C-2114.06
Dup. Neg. No.: L91-10511
LISAR No.: EL-1994-00494
Photo Credit: KSC
Photo Date: 3/20/90
Location: KSC SAEF II
Subject: Postflight Detail of Lower Left of Tray E5

***Figure 419 (Postflight).*** This photograph is of the lower center one-sixth of the tray. The experiment hardware is without physical damage.

Figure 419
Photo No.: KSC-390C-2114.07
Dup. Neg. No.: L91-10512
LISAR No.: EL-1994-00495
Photo Credit: KSC
Photo Date: 3/20/90
Location: KSC SAEF II
Subject: Postflight Detail of Lower Center of Tray E5

***Figure 420 (Postflight).*** This photograph is of the lower right one-sixth of the tray. The experiment hardware is without physical damage.

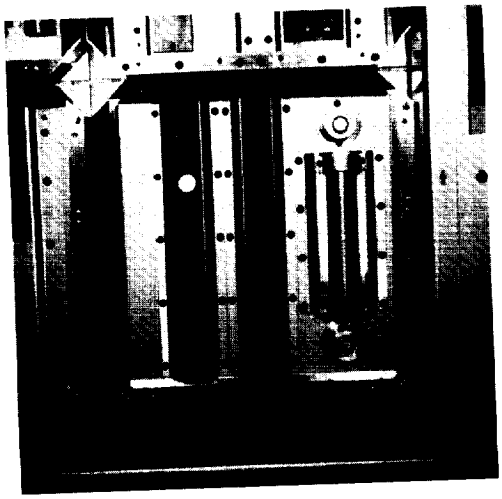

Figure 420
Photo No.: KSC-390C-2114.08
Dup. Neg. No.: L91-10513
LISAR No.: EL-1994-00496
Photo Credit: KSC
Photo Date: 3/20/90
Location: KSC SAEF II
Subject: Postflight Detail of Lower Right of Tray E5

## Tray E6

Multiple Foil Microabrasion Package (MAP) (AO023)

University of Kent

Trays: C3, C9, D12, E6, and H11

The objective of this experiment was to capture micrometeoroids and space debris particles with multiple thin aluminum and brass foil arrays, which ranged in thickness from 1.5 μm to 30 μm. This experiment looked for size, velocity, composition, and distribution of solid particles in the near-Earth environment.

Measurement of Heavy Cosmic Ray Nuclei on LDEF (M0002-2)

University of Kiel

Tray: E6

The objective of this experiment was to measure the elemental and isotopic abundance of heavy cosmic ray nuclei with a nuclear charge equal to or greater than 3.

Ion Beam Textured and Coated Surfaces Experiment (S1003)

NASA LeRC

Tray: E6

The objective of this experiment was to measure the effects of exposure to the Shuttle launch and near-Earth space environments on the optical properties of ion-beam-textured high-absorption solar thermal control surfaces, the optical and electrical properties of ion-beam-sputtered conductive solar thermal control surfaces, and the weight loss of ion-beam-deposited oxide-polymer films.

Balloon Materials Degradation (S1006)

Texas A&M University

Tray: E6

The object of this experiment was to assess the effects of long-term low-Earth-orbit (LEO) exposure on candidate balloon films, tapes, and lines to determine the chemical, morphological, and thermomechanical changes in the polyethylene specimens.

***Figure 421 (Preflight).*** In this photograph, experiment AO023, described in figure 230, is shown in the left one-third section. Experiment S1006 occupies the center one-third section. Experiment M0002-2 is in the lower right section. Experiment S1003 is in the top right section of the 3-in-deep tray. Discolorations are visible on the die-cast frames of experiment AO023. Light reflections cause areas of the thin sensor films of experiment AO023 to appear dark.

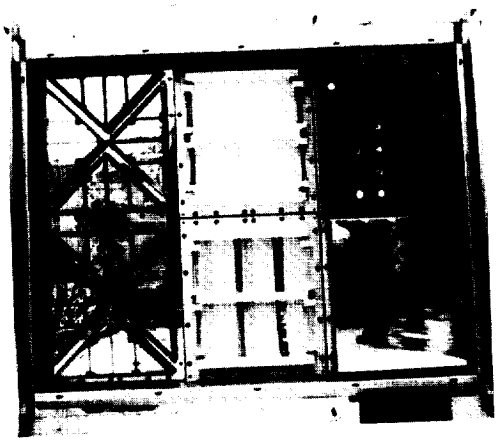

Figure 421
Photo No.: KSC-384C-193.10
Dup. Neg. No.: L84-7068
LISAR No.: EL-1994-00356
Photo Credit: KSC
Photo Date: 1/12/84
Location: KSC SAEF II
Subject: Preflight Survey of Tray E6

***Figure 422 (In Flight).*** The tray clamp dot varies from preflight white at the top to dark brown at the bottom, which is an indication of the transition from leading to trailing side. There are reflections in the foil of the upper sensor of experiment AO023. Low lighting prevents details from being visible in this experiment. The ripples in the Kapton cover foil of experiment M0002-2 that were observed in the prelaunch photograph also appear in the in-flight photographs, but they are at a lower frequency of repetition. The source of discolorations on the aluminized Kapton cover, which appear to be vertical scratches, is unknown. The hardware for experiment S1003 appears to be intact with little or no damage to experiment samples. Many material samples in experiment S1006 have been severely degraded and the base plate is discolored.

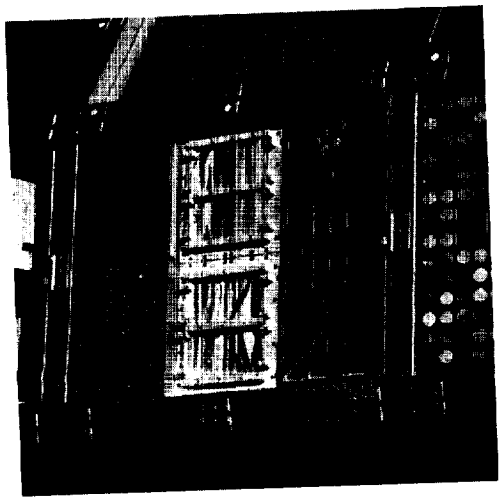

Figure 422
Photo No.: S32-82-006
Dup. Neg. No.: L90-10454
LISAR No.: EL-1994-00024
Photo Credit: JSC
Photo Date: 1/12/90
Location: KSC SAEF II
Subject: In-Flight Survey of Tray E6

***Figure 423 (Postflight).*** Experiment AO023 has no visible physical damage, but the die-cast frames have discolorations. The detector assemblies of experiment M0002-2 appear to be without physical damage. The source of the discolorations on the aluminized Kapton cover, which appear as horizontal scratches and vertical bands, is unknown. The hardware of experiment S1003 appears to be intact and experiment samples appear to have only minor changes. Many of the material samples in experiment S1006 seem to have severely degraded and the base plate is discolored.

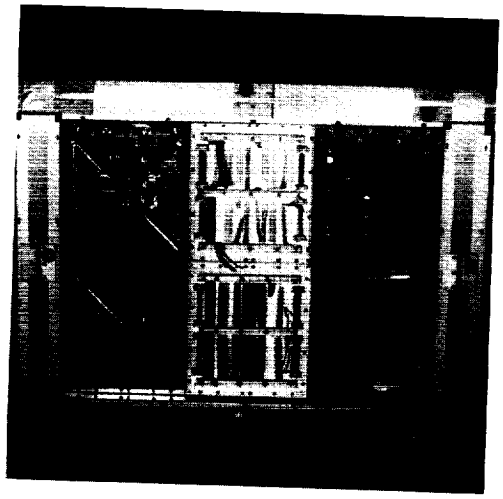

Figure 423
Photo No.: KSC-390C-1033.09
Dup. Neg. No.: L90-13439
LISAR No.: EL-1994-00179
Photo Credit: KSC
Photo Date: 2/9/90
Location: KSC SAEF II
Subject: Postflight Survey of Tray E6

***Figure 424 (Postflight).*** This photograph is of the upper left one-sixth of the tray. The hardware of experiment AO023 is intact. Light reflections are evident in the sensor foil surfaces. There is discoloration on the upper triangular die-cast mounting frame.

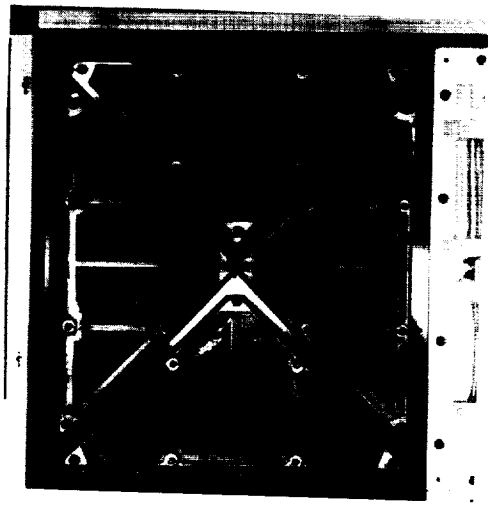

Figure 424
Photo No.: KSC-390C-1992.04
Dup. Neg. No.: L91-10538
LISAR No.: EL-1994-00413
Photo Credit: KSC
Photo Date: 3/15/90
Location: KSC SAEF II
Subject: Postflight Detail of Upper Left of Tray E6

***Figure 425 (Postflight).*** This photograph is of the upper center one-sixth of the tray. The thin-film polymeric material samples in experiment S1006 have been severely degraded. All 26 of the unreinforced thin-film samples have curled edges. Twelve samples appear to have failed in tension and a significant portion of the two aluminized polymer samples appears to be missing. The IITRI S13G-LO white paint on the baseplate has a light tan discoloration.

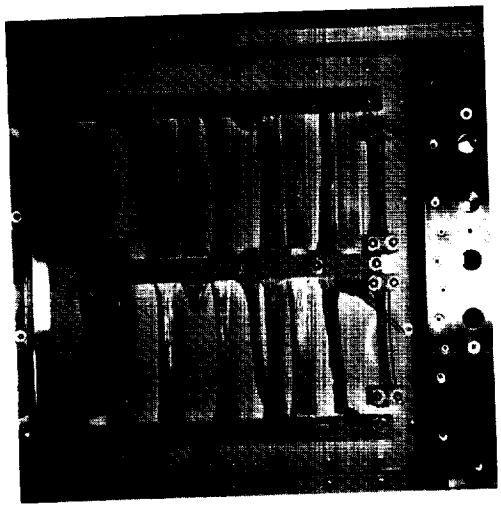

Figure 425
Photo No.: KSC-390C-1992.05
Dup. Neg. No.: L91-10539
LISAR No.: EL-1994-00414
Photo Credit: KSC
Photo Date: 3/15/90
Location: KSC SAEF II
Subject: Postflight Detail of Upper Center of Tray E6

***Figure 426 (Postflight).*** This photograph is of the upper right one-sixth of the tray. The hardware of experiment S1003 is without physical damage and experiment samples have only minor changes. The IITRI S13G-LO white paint sample located second to the right of the lower left corner has changed to light brown and the material sample located second above the lower right corner is partially missing. Other material samples appear in prelaunch condition.

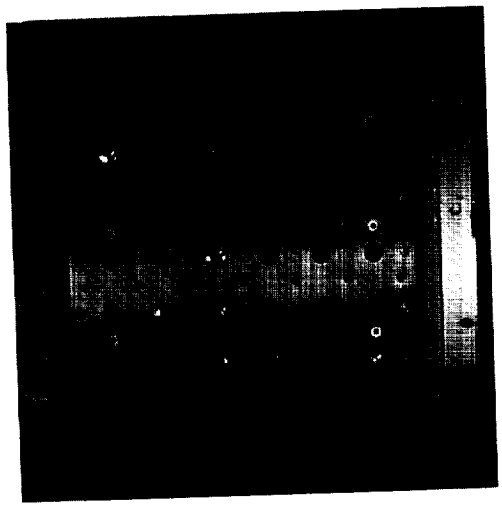

Figure 426
Photo No.: KSC-390C-1992.06
Dup. Neg. No.: L91-10540
LISAR No.: EL-1994-00415
Photo Credit: KSC
Photo Date: 3/15/90
Location: KSC SAEF II
Subject: Postflight Detail of Upper Right of Tray E6

***Figure 427 (Postflight).*** This photograph is of the lower left one-sixth of the tray. The hardware of experiment AO023 is intact. Light reflections are evident in the sensor foil surfaces.

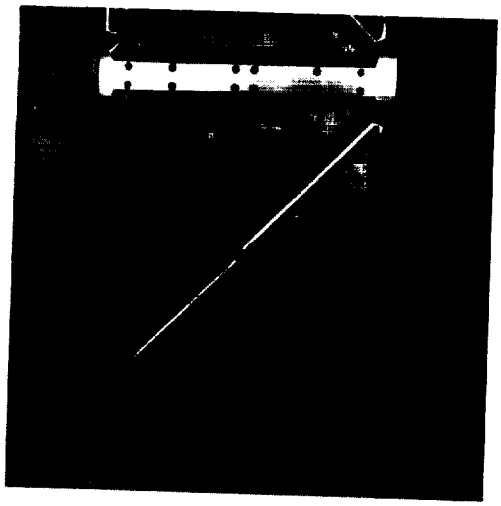

Figure 427
Photo No.: KSC-390C-1992.07
Dup. Neg. No.: L91-10541
LISAR No.: EL-1994-00416
Photo Credit: KSC
Photo Date: 3/15/90
Location: KSC SAEF II
Subject: Postflight Detail of Lower Left of Tray E6

***Figure 428 (Postflight).*** This photograph is of the lower center one-sixth of the tray. The test specimens of experiment S1006 have suffered some degradation. The reinforced thin-film polymer samples are discolored, but they have survived the mission intact. The IITRI S13G-LO white paint on the baseplate has a light tan discoloration in areas that were not covered by experiment samples (with evidence that at least some of the discoloration occurred after sample failure).

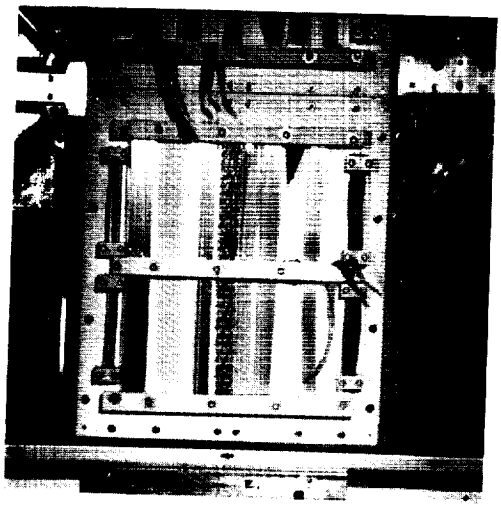

Figure 428
Photo No.: KSC-390C-1992.08
Dup. Neg. No.: L91-10542
LISAR No.: EL-1994-00417
Photo Credit: KSC
Photo Date: 3/15/90
Location: KSC SAEF II
Subject: Postflight Detail of Lower Center of Tray E6

***Figure 429 (Postflight).*** This photograph is of the lower right one-sixth of the tray. Photographic light reflections in the surface are apparent. The experiment appears to have no physical damage from the extended space exposure. The source of discolorations on the aluminized Kapton cover, which appear as horizontal scratches and vertical shadows, is unknown.

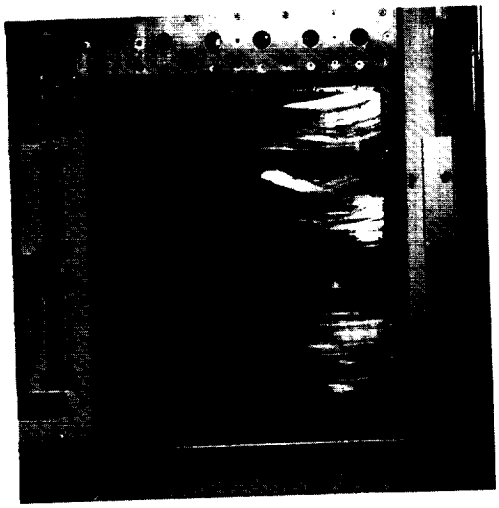

Figure 429
Photo No.: KSC-390C-1992.09
Dup. Neg. No.: L91-10543
LISAR No.: EL-1994-00441
Photo Credit: KSC
Photo Date: 3/15/90
Location: KSC SAEF II
Subject: Postflight Detail of Lower Right of Tray E6

## Tray E7

Space Debris Impact Experiment (S0001)

NASA LaRC

Trays: A5, A6, A12, B1, B2, B6, B8, B11, C4, C7, D2, D6, E1, E4, E7, E11, F1, F3, F5, F7, F10, F11, G4, G8, and H5

See section entitled "Tray A5" for a typical preflight photographic survey and experiment objective.

***Figure 430 (In Flight).*** The discolorations on the lower tray sidewall appear to be fingerprints from handling during experiment assembly. A portion of the pink and greenish-gray tint on the two debris panels are a by-product of the chromic anodize coating process; however, a part of the intensity can be attributed to reflections of the blue sky. The horizontal streaks on the left debris panel and the vertical streaks on the right debris panel are also by-products of chromic anodizing that have been enhanced significantly by the blue reflection.

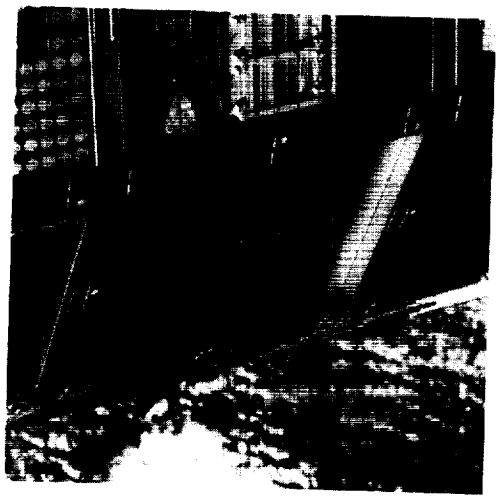

Figure 430
Photo No.: S32-82-032
Dup. Neg. No.: L90-10460
LISAR No.: EL-1994-00040
Photo Credit: JSC
Photo Date: 1/12/90
Location: In Flight
Subject: In-Flight Survey of Tray E7

***Figure 431 (Postflight).*** The pink and greenish-gray tints on the two debris panels are by-products of the chromic anodize coating process and are not attributed to contamination or exposure to the space environment. The streaks on the debris panels that were noted in the in-flight photographs are almost invisible because the reflection of the sky is not present. The light band along the sides and across the bottom of the panels is caused by light reflecting from the tray sidewalls.

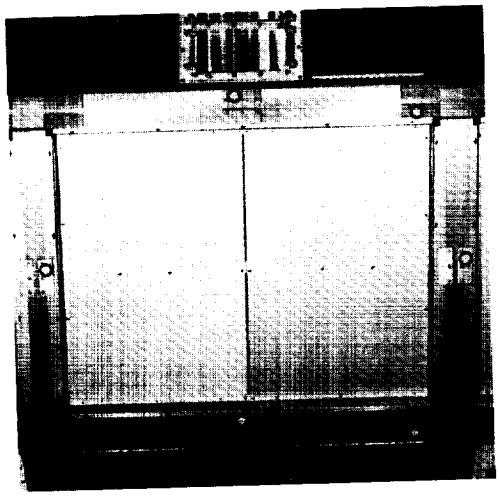

Figure 431
Photo No.: KSC-390C-1032.03
Dup. Neg. No.: L90-13425
LISAR No.: EL-1994-00148
Photo Credit: KSC
Photo Date: 2/9/90
Location: KSC SAEF II
Subject: Postflight Survey of Tray E7

## Tray E8

Chemical and Isotopic Measurements of Micrometeoroids by Secondary Ion Mass Spectrometry (AO187-2)

McDonnell Center for the Space Sciences

Max-Planck Institute for Nuclear Physics

Munich Technical University

Ernst-Mach Institute

Dornier System Manufacturing Company

Trays: C2, E3, and E8

The objective of this experiment was to measure the chemical and the isotopic composition of interplanetary dust particles.

***Figure 432 (Preflight).*** The prelaunch photograph shows 120 capture cells installed on 6 support panels. A capture cell consists of four polished high-purity germanium plates covered with a 2.5-μm thick Mylar foil coated with 1300 A of tantalum that is vapor deposited on the back and 100 A of gold-palladium that is vapor deposited on the front. The capture cells are mounted within an aluminum frame on each panel.

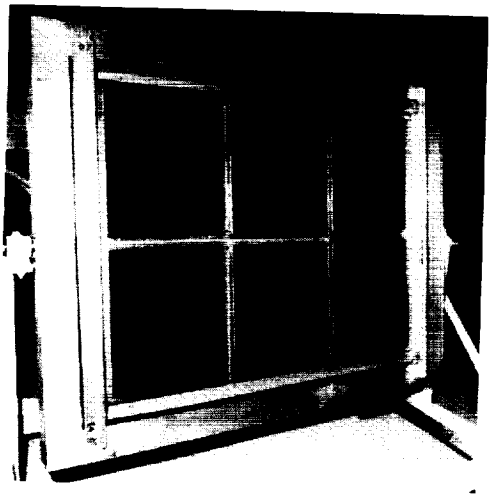

Figure 432
Photo No.: KSC-384C-143.03
Dup. Neg. No.: L84-7045
LISAR No.: EL-1994-00341
Photo Credit: KSC
Photo Date: 1/11/84
Location: KSC SAEF II
Subject: Preflight Survey of Tray E8

***Figure 433 (In Flight).*** The RMS arm of the Shuttle is reflected in the surface of the exposed germanium detector plates. The experiment has severely degraded. The metallic-coated Mylar film covers have failed on each of the capture cells and curled tightly into conical shapes.

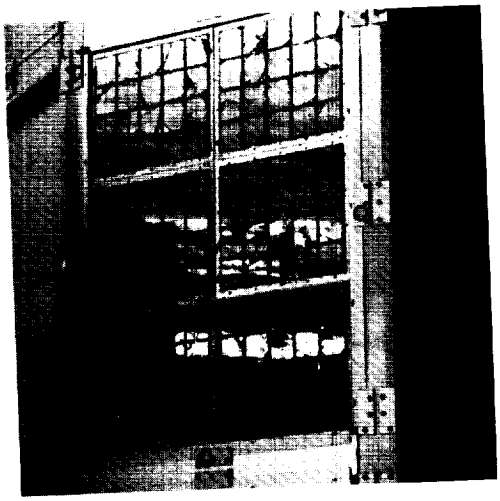

Figure 433
Photo No.: S32-76-016
Dup. Neg. No.: L90-10378
LISAR No.: EL-1994-00663
Photo Credit: JSC
Photo Date: 1/12/90
Location: In Flight
Subject: In-Flight Survey of Tray E8

***Figure 434 (Postflight).*** The metallic-coated thin Mylar film has been lost on each of the capture cells. As the thin Mylar film failed, the material curled tightly into small conical shapes and is still attached to the edges of the aluminum mounting structure. The green tint on the germanium plate at the right edge of the experiment tray is a reflection from the lights in the high bay area of SAEF II. Dim reflections are visible on other sections of the experiment.

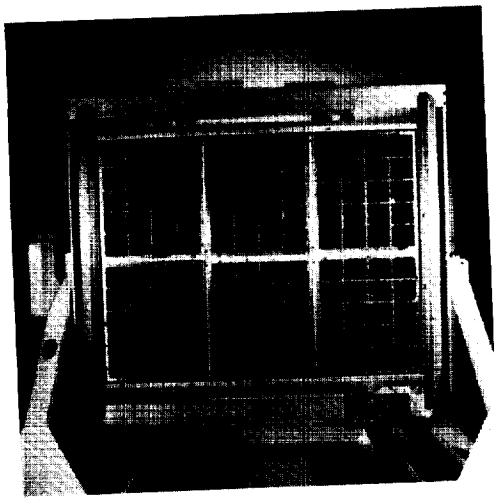

Figure 434
Photo No.: KSC-390C-1767.02
Dup. Neg. No.: L91-10614
LISAR No.: EL-1994-00267
Photo Credit: KSC
Photo Date: 3/90/90
Location: KSC SAEF II
Subject: Postflight Survey of Tray E8

***Figure 435 (Postflight).*** This photograph is of the upper left one-sixth of the tray. The metallic-coated thin Mylar film on all cells has failed and the remnants of the film are hanging loose. A reflection of the surrounding area in the surface of the germanium plates is visible.

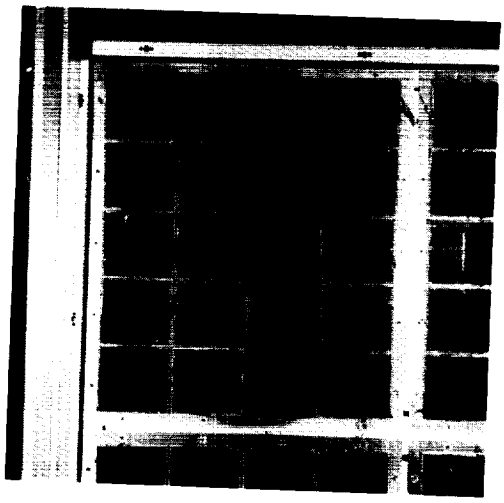

Figure 435
Photo No.: KSC-390C-1767.03
Dup. Neg. No.: L91-10615
LISAR No.: EL-1994-00251
Photo Credit: KSC
Photo Date: 3/9/90
Location: KSC SAEF II
Subject: Postflight Detail of Upper Left of Tray E8

***Figure 436 (Postflight).*** This photograph is of the upper center one-sixth of the tray. The metallic-coated thin Mylar film on all cells has failed and the remnants of the film are hanging loose. A reflection of the surrounding area in the surface of the germanium plates is visible.

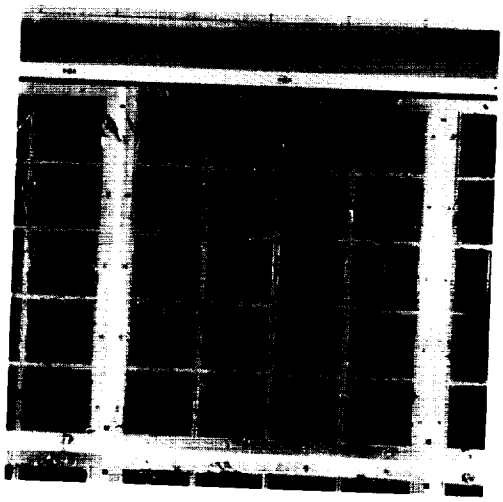

Figure 436
Photo No.: KSC-390C-1767.04
Dup. Neg. No.: L91-10616
LISAR No.: EL-1994-00252
Photo Credit: KSC
Photo Date: 3/9/90
Location: KSC SAEF II
Subject: Postflight Detail of Upper Center of Tray E8

***Figure 437 (Postflight).*** This photograph is of the upper right one-sixth of the tray. The metallic-coated thin Mylar film on all cells has failed and the remnants of the film are hanging loose. A reflection of the surrounding area in the surface of the germanium plates is visible.

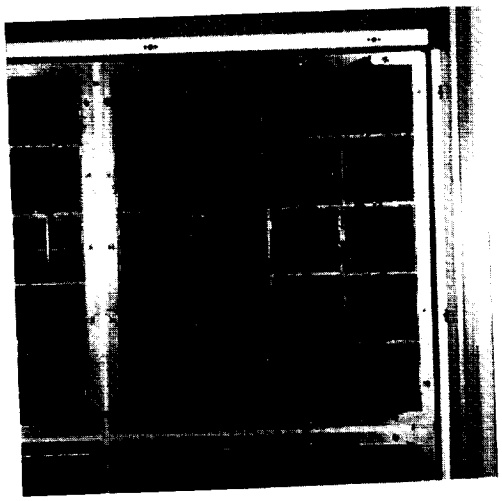

Figure 437
Photo No.: KSC-390C-1767.05
Dup. Neg. No.: L91-10617
LISAR No.: EL-1994-00253
Photo Credit: KSC
Photo Date: 3/9/90
Location: KSC SAEF II
Subject: Postflight Detail of Upper Right of Tray E8

***Figure 438 (Postflight).*** This photograph is of the lower left one-sixth of the tray. The metallic-coated thin Mylar film on all cells has failed and the remnants of the film are hanging loose. A reflection of the surrounding area in the surface of the germanium plates is visible.

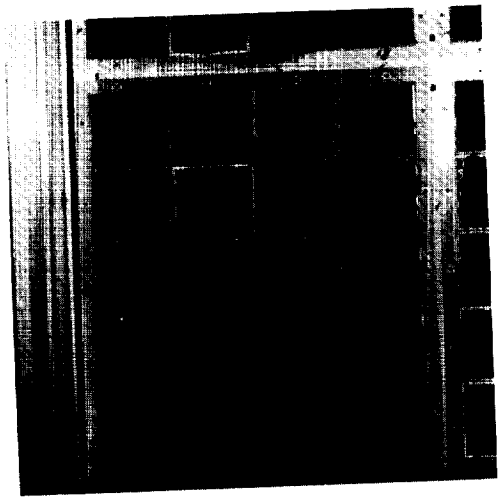

Figure 438
Photo No.: KSC-390C-1767.06
Dup. Neg. No.: L91-10618
LISAR No.: EL-1994-00254
Photo Credit: KSC
Photo Date: 3/9/90
Location: KSC SAEF II
Subject: Postflight Detail of Lower Left of Tray E8

***Figure 439 (Postflight).*** This photograph is of the lower center one-sixth of the tray. The metallic-coated thin Mylar film on all cells has failed and the remnants of the film are hanging loose. A reflection of the surrounding area in the surface of the germanium plates is visible.

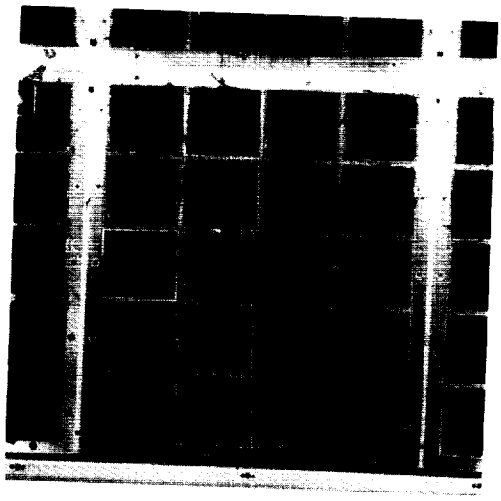

Figure 439
Photo No.: KSC-390C-1767.07
Dup. Neg. No.: L91-10619
LISAR No.: EL-1994-00255
Photo Credit: KSC
Photo Date: 3/9/90
Location: KSC SAEF II
Subject: Postflight Detail of Lower Center of Tray E8

***Figure 440 (Postflight).*** This photograph is of the lower right one-sixth of the tray. The metallic-coated thin Mylar film on all cells has failed and the remnants of the film are hanging loose. A reflection of the surrounding area in the surface of the germanium plates is visible.

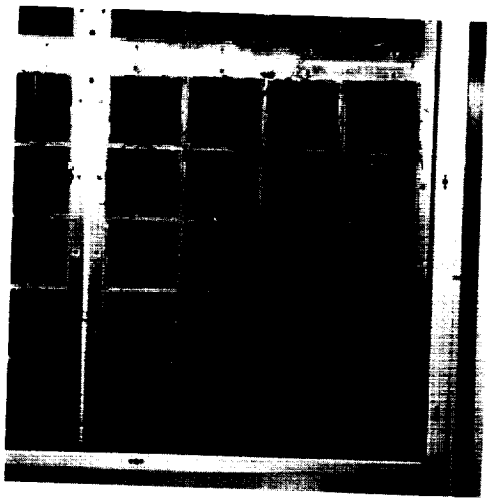

Figure 440
Photo No.: KSC-390C-1767.08
Dup. Neg. No.: L91-10620
LISAR No.: EL-1994-00256
Photo Credit: KSC
Photo Date: 3/9/90
Location: KSC SAEF II
Subject: Postflight Detail of Lower Right of Tray E8

## Tray E9

Advanced Photovoltaic Experiment (APEX) (S0014)

NASA LeRC

Tray: E9

The objective was to provide information on the performance and endurance of advanced and conventional solar cells, to improve reference standards for photovoltaic measurements, and to measure the energy distribution in the extraterrestrial solar spectrum.

***Figure 441 (Preflight).*** Experiment S0014 included 155 solar cells mounted on 127 removable aluminum plates of 12 different sizes, an Eppley Type HF cavity radiometer, a digital solar angle sensor, a dichroic mirror assembly, a night or dark sensor, a row of 16 bandpass filters clamped over silicon solar cell sensors, 2 ultraviolet exposure monitors, and 2 concentrator cells with vapor-deposited aluminum (on Kapton film and Mylar foil) mirrors. An aluminum substructure provided a mounting surface for the experiment components and controlled the field of view of the solar cells. The experiment structure was painted with Chemglaze Z-306 flat black paint over a Chemglaze 9924 wash primer.

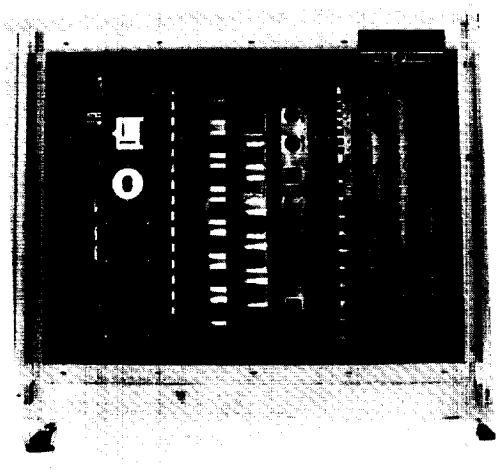

Figure 441
Preflight Survey of Tray E9
Photo No.: KSC-384C-193.01
Dup. Neg. No.: L84-7059
LISAR No.: EL-1994-00343
Photo Credit: KSC
Photo Date: 1/12/84
Location: KSC SAEF II
Subject: Preflight Survey of Tray E9

***Figure 442 (In Flight).*** The Chemglaze Z-306 black paint on the exposed surfaces has degraded, thus leaving the Chemglaze 9924 primer, which is reddish brown, clearly visible. The difference in the amount of paint remaining may be a function of initial paint thickness; the plate covering the center section was not painted at the same time as the other two plates. The experiment appears intact with little, if any damage.

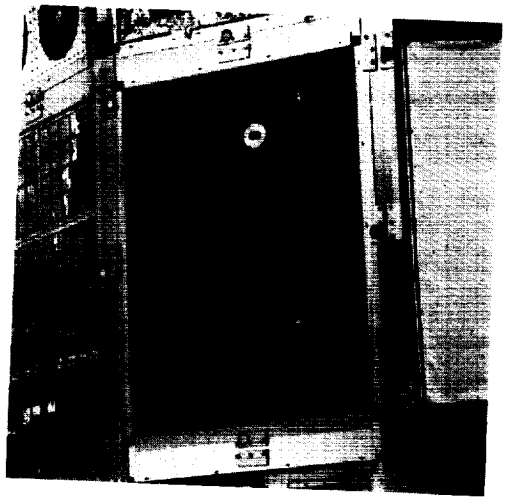

Figure 442
Photo No.: S32-78-090
Dup. Neg. No.: L90-10449
LISAR No.: EL-1994-00021
Photo Credit: JSC
Photo Date: 1/12/90
Location: In Flight
Subject: In-Flight Survey of Tray E9

***Figure 443 (Postflight).*** The degradation of the Chemglaze Z-306 black paint on the exposed surfaces is evident by the amount of Chemglaze 9924 primer, which is reddish brown, that is visible. The difference in the amount of paint remaining may be a function of initial paint thickness; the plate covering the center section of the tray was not painted at the same time as the other two plates. The small gold-colored rectangular plate in the lower right section of the tray was fabricated from an aluminum alloy and coated with a clear anodize. A light brown discoloration is visible on the solar cell mounting plates and on areas of the aluminum base structure.

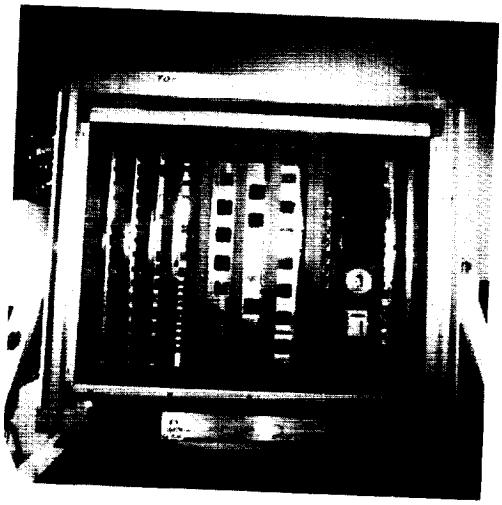

Figure 443
Photo No.: KSC-390C-1840.10
Dup. Neg. No.: L91-10676
LISAR No.: EL-1994-00279
Photo Credit: KSC
Photo Date: 3/12/90
Location: KSC SAEF II
Subject: Postflight Survey of Tray E9

***Figure 444 (Postflight).*** This close-up photograph is of the two left rows. No physical damage is evident.

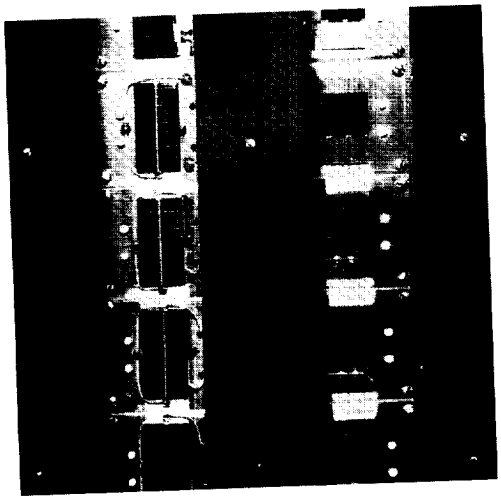

Figure 444
Photo No.: KSC-390C-1842.03
Dup. Neg. No.: L91-10681
LISAR No.: EL-1994-00408
Photo Credit: KSC
Photo Date: 3/12/90
Location: KSC SAEF II
Subject: Postflight Detail of Left Two Rows of Tray E9

***Figure 445 (Postflight).*** This close-up photograph is of the third and the fourth rows. No physical damage is evident.

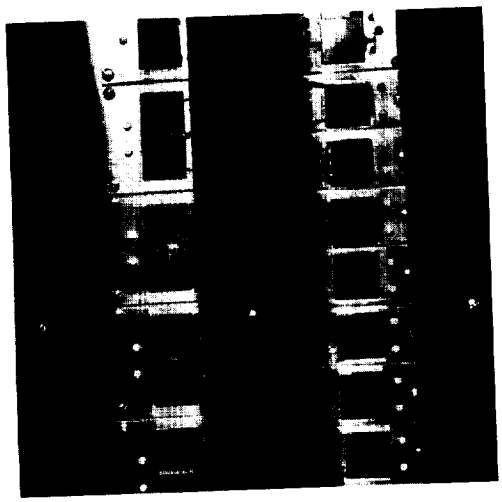

Figure 445
Photo No.: KSC-390C-1842.07
Dup. Neg. No.: L91-10685
LISAR No.: EL-1994-00418
Photo Credit: KSC
Photo Date: 3/12/90
Location: KSC SAEF II
Subject: Postflight Detail of Third and Fourth Rows of Tray E9

***Figure 446 (Postflight).*** This close-up photograph is of the fifth row. There appears to be no physical damage, but some brown discoloration around the edges of the solar cells is evident.

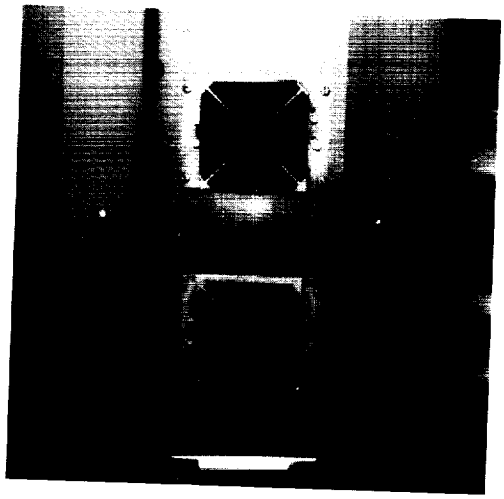

Figure 446
Photo No.: KSC-390C-1835.02
Dup. Neg. No.: L91-10633
LISAR No.: EL-1994-00398
Photo Credit: KSC
Photo Date: 3/12/90
Location: KSC SAEF II
Subject: Postflight Detail of Fifth Row of Tray E9

***Figure 447 (Postflight).*** This close-up photograph is of the sixth row. There appears to be no physical damage, but some brown discoloration around the edges of the solar cells is evident.

Figure 447
Photo No.: KSC-390C-1835.05
Dup. Neg. No.: L91-10636
LISAR No.: EL-1994-00399
Photo Credit: KSC
Photo Date: 3/12/90
Location: KSC SAEF II
Subject: Postflight Detail of Sixth Row of Tray E9

***Figure 448 (Postflight).*** This close-up photograph is of the seventh row. There appears to be no physical damage, but some brown discoloration around the edges of the solar cells is evident.

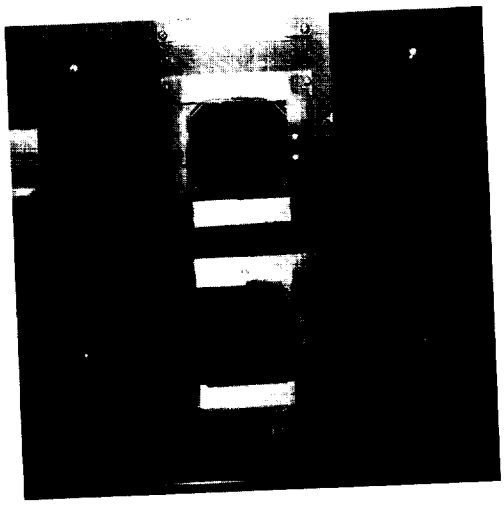

Figure 448
Photo No.: KSC-390C-1835.09
Dup. Neg. No.: L91-10640
LISAR No.: EL-1994-00400
Photo Credit: KSC
Photo Date: 3/12/90
Location: KSC SAEF II
Subject: Postflight Detail of Seventh Row of Tray E9

***Figure 449 (Postflight).*** This close-up is of the ninth row. A solar concentrator cell, located at the lower end of the slot, appears to be damaged. The large piece of gold-colored material lodged in the slot appears to be a segment of the aluminum deposited on the Kapton mirror.

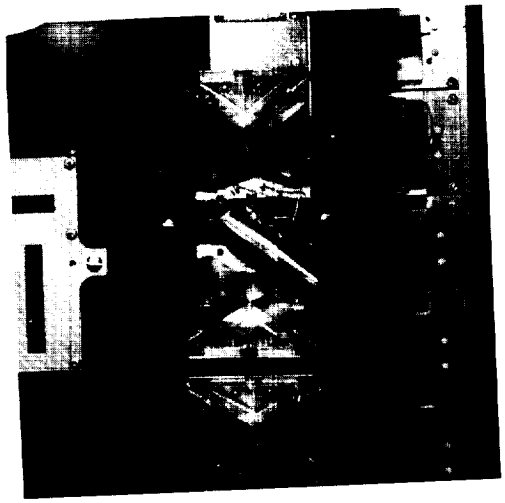

Figure 449
Photo No.: KSC-390C-1837.07
Dup. Neg. No.: L91-10657
LISAR No.: EL-1994-00402
Photo Credit: KSC
Photo Date: 3/12/90
Location: KSC SAEF II
Subject: Postflight Detail of Ninth Row of Tray E9

***Figure 450 (Postflight).*** This close-up photograph is of the tenth row. There appears to be no physical damage, but the cell mounting frames have a mottled brown discoloration.

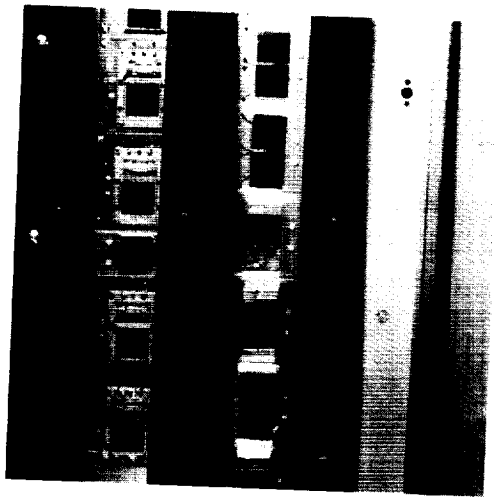

Figure 450
Photo No.: KSC-390C-1837.11
Dup. Neg. No.: L91-10661
LISAR No.: EL-1994-00403
Photo Credit: KSC
Photo Date: 3/12/90
Location: KSC SAEF II
Subject: Postflight Detail of Tenth Row of Tray E9

## Tray E10

A High-Resolution Study of Ultraheavy Cosmic Ray Nuclei (UHCRE) (AO178)

Dublin Institute for Advanced Studies

ESA at ESTEC

Trays: A2, A4, A10, B5, B7, C5, C6, C8, C11, D1, D5, D7, D11, E2, E10, and F4

See section entitled "Tray D5" and figure 314 for a typical preflight photograph of experiment AO178.

***Figure 451 (In Flight).*** The surface of the thermal cover appears to have changed from specular to opaque with numerous black dots of various sizes, thus indicating impacts or penetrations. The cover is taut and the locations of Velcro attachment pads are prominent. The ground strap has no visible damage, but is a deeper copper color.

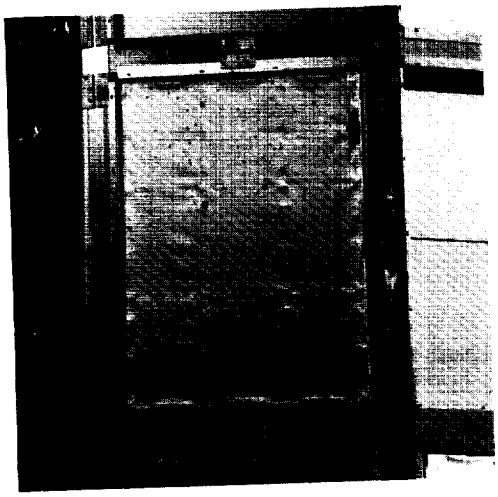

Figure 451
Photo No.: S32-78-083
Dup. Neg. No.: L90-10447
LISAR No.: EL-1994-00019
Photo Credit: JSC
Photo Date: 1/12/90
Location: In Flight
Subject: In-Flight Survey of Tray E10

***Figure 452 (Postflight).*** The surface of the thermal cover appears to have changed from specular to opaque with numerous black dots of various sizes, thus indicating space debris impacts or penetrations. The cover is less taut than in flight. The locations of Velcro attachment pads are visible. The pinkish green tint on the thermal cover is caused by the lighting and reflections from the surroundings. The arm of the RMS that is cradled in the Shuttle is visible at the bottom.

Figure 452
Photo No.: KSC-390C-612.05
Dup. Neg. No.: L92-17796
LISAR No.: EL-1994-00162
Photo Credit: KSC
Photo Date: 1/30/90
Location: KSC OPF
Subject: Postflight Survey of Tray E10

***Figure 453 (Postflight).*** This photograph is of the upper left one-sixth of the tray. The thermal cover is now opaque and not as highly reflective as it was in the preflight photograph. There are numerous black dots of various sizes that indicate space debris impacts or penetrations. The thermal cover Velcro attachment pads are evident.

Figure 453
Photo No.: KSC-390C-2281.02
Dup. Neg. No.: L91-10711
LISAR No.: EL-1994-00620
Photo Credit: KSC
Photo Date: 3/23/90
Location: KSC SAEF II
Subject: Postflight Detail of Upper Left of Tray E10

***Figure 454 (Postflight).*** This photograph is of the upper center one-sixth of the tray. The thermal cover is now opaque and not as highly reflective as it was in the preflight photograph. There are numerous black dots of various sizes that indicate space debris impacts or penetrations. The thermal cover Velcro attachment pads are evident.

Figure 454
Photo No.: KSC-390C-2281.03
Dup. Neg. No.: L91-10712
LISAR No.: EL-1994-00561
Photo Credit: KSC
Photo Date: 3/23/90
Location: KSC SAEF II
Subject: Postflight Detail of Upper Center of Tray E10

***Figure 455 (Postflight).*** This photograph is of the upper right one-sixth of the tray. The thermal cover is now opaque and not as highly reflective as it was in the preflight photograph. There are numerous black dots of various sizes that indicate space debris impacts or penetrations. The thermal cover Velcro attachment pads are evident.

Figure 455
Photo No.: KSC-390C-2281.04
Dup. Neg. No.: L91-10713
LISAR No.: EL-1994-00562
Photo Credit: KSC
Photo Date: 3/23/90
Location: KSC SAEF II
Subject: Postflight Detail of Upper Right of Tray E10

***Figure 456 (Postflight).*** This photograph is of the lower left one-sixth of the tray. The thermal cover is now opaque and not as highly reflective as it was in the preflight photograph. There are numerous black dots of various sizes that indicate space debris impacts or penetrations. The thermal cover Velcro attachment pads are evident.

Figure 456
Photo No.:
KSC-390C-2281.08
Dup. Neg. No.: L91-10717
LISAR No.: EL-1994-00563
Photo Credit: KSC
Photo Date: 3/23/90
Location: KSC SAEF II
Subject: Postflight Detail of Lower Left of Tray E10

***Figure 457 (Postflight).*** This photograph is of the lower center one-sixth of the tray. The thermal cover is now opaque and not as highly reflective as it was in the preflight photograph. There are numerous black dots of various sizes that indicate space debris impacts or penetrations. The thermal cover Velcro attachment pads are evident.

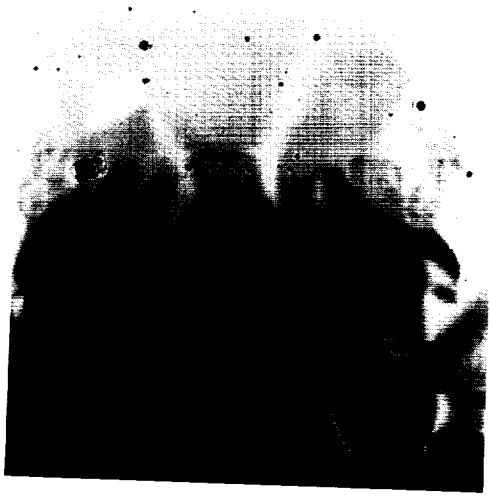

Figure 457
Photo No.: KSC-390C-2281.09
Dup. Neg. No.: L91-10718
LISAR No.: EL-1994-00564
Photo Credit: KSC
Photo Date: 3/23/90
Location: KSC SAEF II
Subject: Postflight Detail of Lower Center of Tray E10

***Figure 458 (Postflight).*** This photograph is of the lower right one-sixth of the tray. The thermal cover is now opaque and not as highly reflective as it was in the preflight photograph. There are numerous black dots of various sizes that indicate space debris impacts or penetrations. The thermal cover Velcro attachment pads are evident.

Figure 458
Photo No.: KSC-390C-2281.10
Dup. Neg. No.: L91-10719
LISAR No.: EL-1994-00565
Photo Credit: KSC
Photo Date: 3/23/90
Location: KSC SAEF II
Subject: Postflight Detail of Lower Right of Tray E10

***Figure 459 (Postflight).*** This close-up photograph is of the large discolored area at the edge of the thermal cover near the lower right corner of the tray.

Figure 459
Photo No.: KSC-390C-2281.11
Dup. Neg. No.: L91-10720
LISAR No.: EL-1994-00566
Photo Credit: KSC
Photo Date: 3/23/90
Location: KSC SAEF II
Subject: Postflight Detail of Discoloration in Lower Right of Tray E10

***Figure 460 (Postflight).*** This photograph is of tray E10 after the thermal cover has been removed. Note the spots visible on the upper cylinders. These discolorations occurred behind penetrations of the thermal cover. The frame with the Velcro pads for attaching the thermal cover is visible.

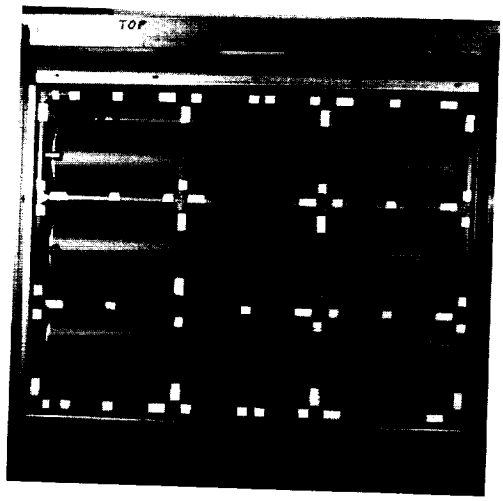


Figure 460
Photo No.: KSC-390C-2321.03
Dup. Neg. No.: L91-10729
LISAR No.: EL-1994-00712
Photo Credit: KSC
Photo Date: 3/26/90
Location: KSC SAEF II
Subject: Postflight Detail of Tray E10

## Tray E11

Space Debris Impact Experiment (S0001)

NASA LaRC

Trays: A5, A6, A12, B1, B2, B6, B8, B11, C4, C7, D2, D6, E1, E4, E7, E11, F1, F3, F5, F7, F10, F11, G4, G8, and H5

See section entitled "Tray A5" for a typical preflight photographic survey and experiment objective.

***Figure 461 (In Flight).*** A portion of the pink and greenish-gray tint on the two debris panels is a by-product of the chromic anodize coating process; however, part of the intensity can be attributed to reflections of the blue sky. The vertical streaks on the debris panel are by-products of chromic anodizing that have been enhanced by the blue reflection. The light band along the vertical edge of the left debris panel is a reflection from the tray sidewall.

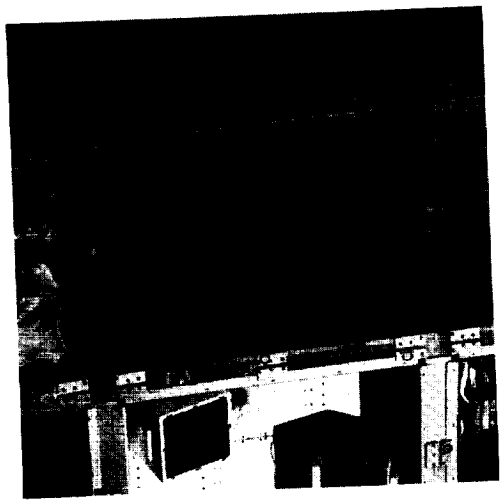

Figure 461
Photo No.: S32-78-053
Dup. Neg. No.: L90-10436
LISAR No.: EL-1994-00012
Photo Credit: JSC
Photo Date: 1/12/90
Location: In Flight
Subject: In-Flight Survey of Tray E11

***Figure 462 (Postflight).*** The pink and greenish-gray tints on the two debris panels are by-products of the chromic anodize coating process and are not attributed to contamination or exposure to the space environment. The vertical streaks observed on the debris panels in the in-flight photograph are no longer visible because the reflection of the sky is not present. Debris from other experiments that were significantly degraded during the mission are visible on the lower experiment tray sidewall at the intersection with the lower edge of the debris panels. Other experiment debris, visible as dark specks, are at the intersection of the debris panel outer edges and the tray sidewalls. The light band along the sides and across the bottom of the panels is caused by light reflecting from the tray sidewalls.

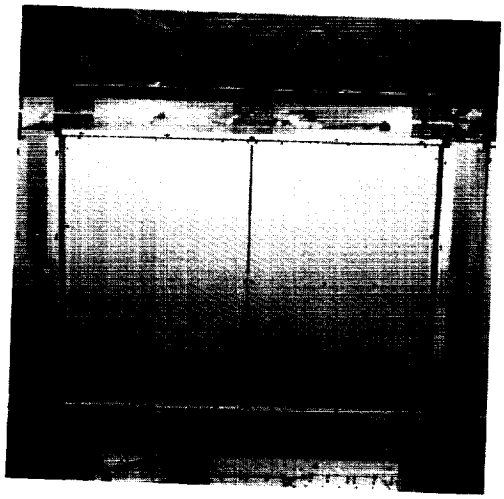

Figure 462
Photo No.: KSC-390C-1028.04
Dup. Neg. No.: L90-13378
LISAR No.: EL-1994-00140
Photo Credit: KSC
Photo Date: 2/9/90
Photo Location: KSC SAEF II
Subject: Postflight Survey of Tray E11

## Tray E12

Interstellar Gas Experiment (AO038)

JSC

University of Bern

Trays: E12, F6, H6, and H9

Experiment AO038 was designed to collect and isotopically analyze the noble gases in the particle wind that is formed as the local interstellar medium moves through the inner solar system.

***Figure 463 (Preflight).*** The prelaunch photograph of the hardware for experiment AO038 shows the orientation of two experiment canister housings that were mounted in a 12-in-deep peripheral tray. The canisters contained high-purity beryllium copper collecting foils. The aluminum housing covers, which were removed prior to flight, protected experiment components from damage and large particle contamination during ground handling. The tray is painted white to provide the necessary thermal control.

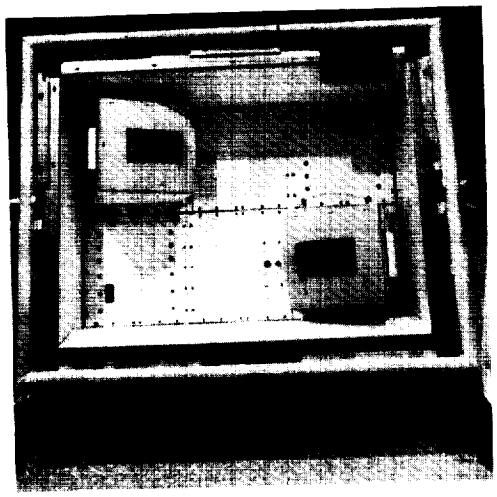

Figure 463
Photo No.: KSC-384C-538.12
Dup. Neg. No.: L89-4424
LISAR No.: EL-1994-00045
Photo Credit: KSC
Photo Date: 1/30/84
Location: KSC SAEF II
Subject: Preflight Survey of Tray E12

***Figure 464 (In Flight).*** The color of the thermal control paint on experiment AO038 has changed and now varies from white to shades of brown. The shadows from the tray sidewalls hide most of the dark stain in the upper right corner of the tray.

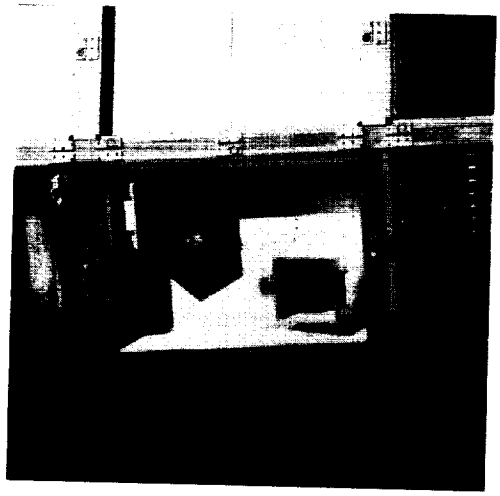

Figure 464
Photo No.: S32-78-031
Dup. Neg. No.: L90-10431
LISAR No.: EL-1994-00007
Photo Credit: JSC
Photo Date: 1/12/90
Location: In Flight
Subject: In-Flight Survey of Tray E12

***Figure 465 (Postflight).*** Brown stains are prominent, especially around the openings in the baseplate for the grid voltage cable connectors. The beryllium copper collector foils are clearly visible in this photograph, as are the baffles near the top of the canister housing. However, the fine wire mesh grid is not visible. Because of an experiment system malfunction, the canister collector foils that are visible were exposed for the total mission.

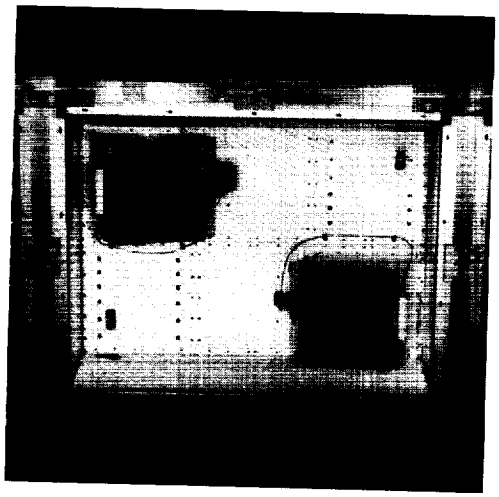

Figure 465
Photo No.: KSC-390C-1069.09
Dup. Neg. No.: L90-13489
LISAR No.: EL-1994-00201
Photo Credit: KSC
Photo Date: 2/8/90
Location: KSC SAEF II
Subject: Postflight Survey of Tray E12

***Figure 466 (Postflight).*** This photograph is of the upper left one-sixth of the tray. Note the brown discoloration in the tray corner and around the grid voltage plug to the right of the canister. The cover was installed on the canister housing to protect the space-exposed hardware.

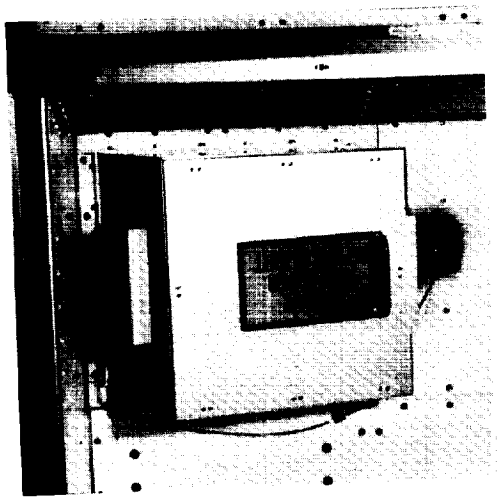

Figure 466
Photo No.: KSC-390C-1600.03
Dup. Neg. No.: L91-10783
LISAR No.: EL-1994-00117
Photo Credit: KSC
Photo Date:3/5/90
Location: KSC SAEF II
Subject: Postflight Detail of Upper Left of Tray E12

***Figure 467 (Postflight).*** This photograph is of the upper center one-sixth of the tray. Note the brown discoloration around the grid voltage plug to the right of the canister. The cover was installed on the canister housing to protect the space-exposed hardware.

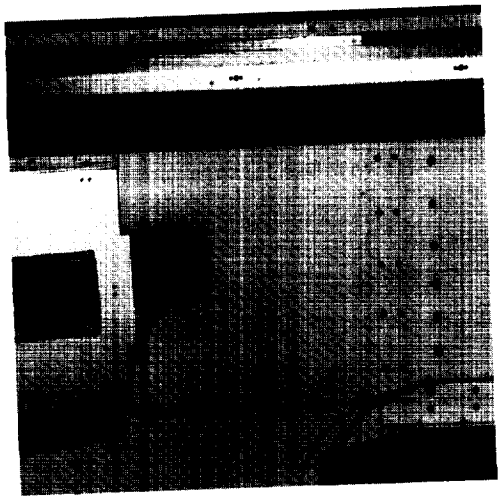

Figure 467
Photo No.: KSC-390C-1600.04
Dup. Neg. No.: L91-10784
LISAR No.: EL-1994-00118
Photo Credit: KSC
Photo Date: 3/5/90
Location: KSC SAEF II
Subject: Postflight Detail of Upper Center of Tray E12

***Figure 468 (Postflight).*** This photograph is of the upper right one-sixth of the tray. Note the light brown discoloration in the tray corner.

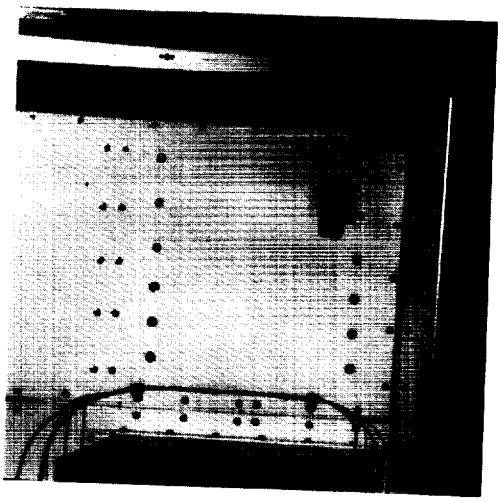

Figure 468
Photo No.: KSC-390C-1600.05
Dup. Neg. No.: L91-10785
LISAR No.: EL-1994-00157
Photo Credit: KSC
Photo Date: 3/5/90
Location: KSC SAEF II
Subject: Postflight Detail of Upper Right of Tray E12

***Figure 469 (Postflight).*** This photograph is of the lower right one-sixth of the tray. Note the brown discoloration around the grid voltage plug to the left of the canister. The cover was installed on the canister housing to protect the space-exposed hardware.

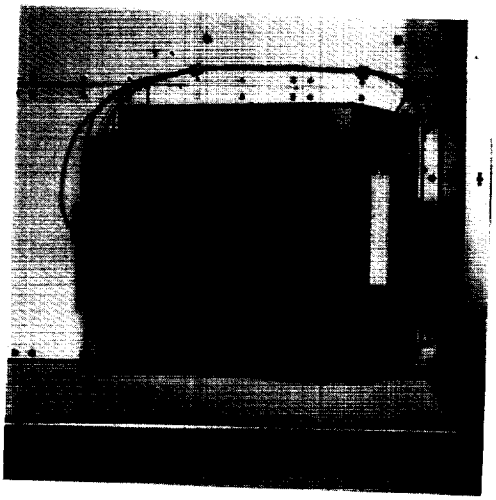

Figure 469
Photo No.: KSC-390C-1600.06
Dup. Neg. No.: L91-10786
LISAR No.: EL-1994-00158
Photo Credit: KSC
Photo Date: 3/5/90
Location: KSC SAEF II
Subject: Postflight Detail of Lower Right of Tray E12

***Figure 470 (Postflight).*** This photograph is of the lower center one-sixth of the tray. Note the brown discoloration around the grid voltage plug to the left of the canister. The cover was installed on the canister housing to protect the space-exposed hardware.

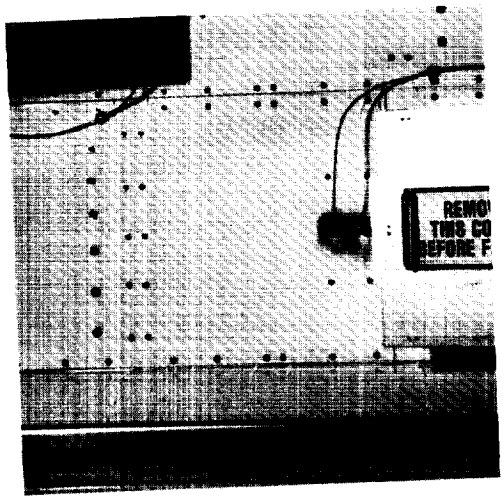

Figure 470
Photo No.: KSC-390C-1600.07
Dup. Neg. No.: L91-10787
LISAR No.: EL-1994-00159
Photo Credit: KSC
Photo Date: 3/5/90
Location: KSC SAEF II
Subject: Postflight Detail of Lower Center of Tray E12

***Figure 471 (Postflight).*** This photograph is of the lower left one-sixth of the tray. There is little, if any, discoloration present.

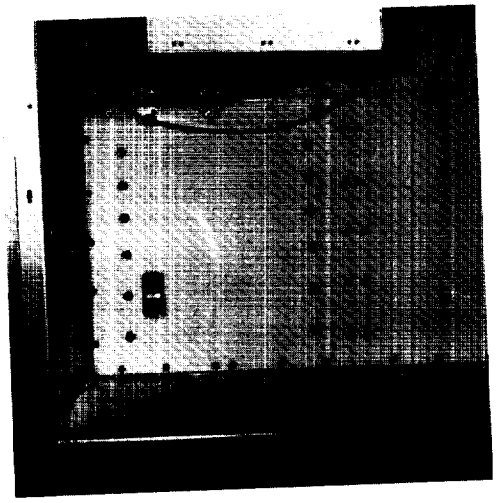

Figure 471
Photo No.: KSC-390C-1600.08
Dup. Neg. No.: L91-10788
LISAR No.: EL-1994-00160
Photo Credit: KSC
Photo Date: 3/5/90
Location: KSC SAEF II
Subject: Postflight Detail of Lower Left of Tray E12

***Figure 472 (Postflight).*** This close-up photograph is of the lower right corner canister. Note the discoloration around the grid voltage plug and the well-defined discoloration pattern on the tray wall.

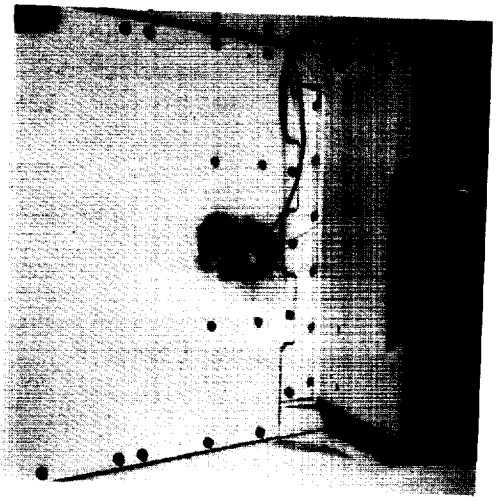

Figure 472
Photo No.: KSC-390C-1601.08
Dup. Neg. No.: L91-10775
LISAR No.: EL-1994-00098
Photo Credit: KSC
Photo Date: 3/5/90
Location: KSC SAEF II
Subject: Postflight Detail of Lower Right Corner Canister of Tray E12

***Figure 473 (Postflight).*** This close-up photograph is of the grid voltage plug that was located to the right of the upper left canister. Note the dark discoloration and the small piece of debris from one of the other experiments.

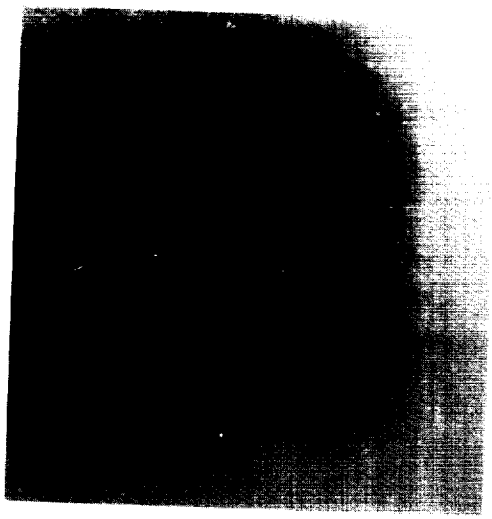

Figure 473
Photo No.: KSC-390C-1602.04
Dup. Neg. No.: L91-10795
LISAR No.: EL-1994-00654
Photo Credit: KSC
Photo Date: 3/5/90
Location: KSC SAEF II
Subject: Postflight Detail of Grid Voltage Plug Of Upper Left Canister of E12

***Figure 474 (Postflight).*** This close-up photograph is of the grid voltage plug that was located to the right of the upper left canister. Note the discolored area around the plug and the discoloration pattern on the canister wall.

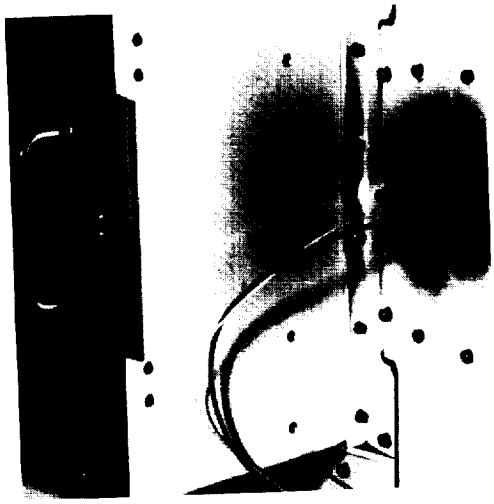

Figure 474
Photo No.: KSC-390C-1602.05
Dup. Neg. No.: L91-10796
LISAR No.: EL-1994-00655
Photo Credit: KSC
Photo Date: 3/5/90
Location: KSC SAEF II
Subject: Postflight Detail of Grid Voltage Plug Located to Right of Upper Left Canister of Tray E12

## Tray F1

Space Debris Impact Experiment (S0001)

NASA LaRC

Trays: A5, A6, A12, B1, B2, B6, B8, B11, C4, C7, D2, D6, E1, E4, E7, E11, F1, F3, F5, F7, F10, F11, G4, G8, and H5

See section entitled "Tray A5" for a typical preflight photographic survey and experiment objective.

***Figure 475 (In Flight).*** A portion of the greenish-gray tint on the two debris panels is a by-product of the chromic anodize coating process; however, a large part can be attributed to reflections of the blue sky. The vertical streaks in the panels are by-products of chromic anodizing that have been enhanced significantly by the blue reflection. Two darker blue horizontal discolorations are visible near the vertical center of each panel.

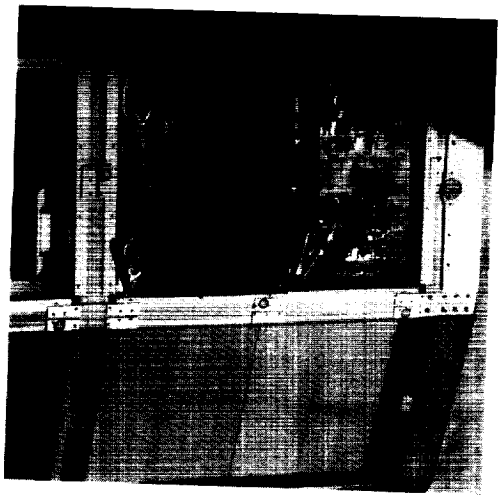

Figure 475
Photo No.: S32-78-036
Dup. Neg. No.: L90-10432
LISAR No.: EL-1994-00008
Photo Credit: JSC
Photo Date: 1/12/90
Location: In Flight
Subject: In-Flight Survey of Tray F1

***Figure 476 (Postflight).*** The pink and greenish-gray tints on the two debris panels are by-products of the chromic anodize coating process and are not attributed to contamination or exposure to the space environment. The vertical streaks that were on the panels in the in-flight photograph are still visible, but they are much lighter because the reflection of the sky is not present. The same can be said for the two discolorations; they are still visible, but are much lighter. The light band along the sides and across the bottom of the panels is caused by light reflecting from the tray sidewalls.

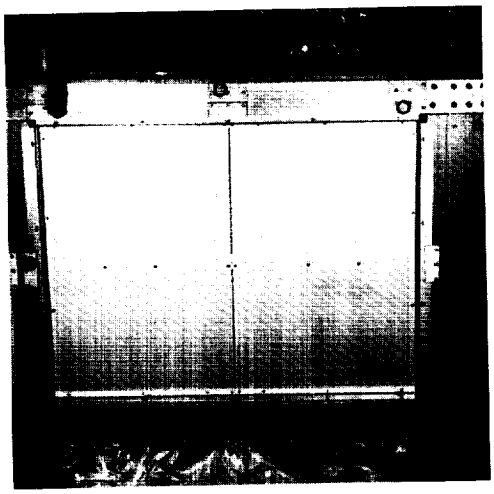

Figure 476
Photo No.: KSC-390C-1066.07
Dup. Neg. No.: L90-13476
LISAR No.: EL-1994-00186
Photo Credit: KSC
Photo Date: 2/8/90
Location: KSC SAEF II
Subject: Postflight Survey of Tray F1

## Tray F2

Seeds in Space Experiment (P0004-1)

George W. Park Seed Company, Inc.

Tray: F2

The objectives of this experiment were to evaluate the effects of space radiation on the survivability of seed stored in space under sealed and vented conditions and to determine the possible resulting mutations and mutation rates.

Space-Exposed Experiment Developed for Students (SEEDS) (P0004-2)

NASA Headquarters

Tray: F2

The objectives of this experiment were to involve a very large number of students in a national project to generate interest in science and related disciplines; to offer students from the elementary level through the university level an opportunity to participate firsthand in an experiment with materials flown in space; to permit active involvement in classroom experiment design, decision making, data gathering, and comparison of results; and to emphasize a multidisciplinary approach to the project involving subject areas other than science.

Linear Energy Transfer Spectrum Measurement Experiment (P0006)

University of San Francisco

NASA MSFC

Tray: F2

The objective of the experiment was to measure the linear energy transfer (LET) spectrum behind different shielding configurations.

***Figure 477 (Preflight).*** This photograph is of the tray before the thermal cover was installed. Experiment P0004-1 was housed in the smaller cylindrical canister to the right of center and in the upper center dome-shaped canister. Experiment P0006 was housed in the smaller cylindrical canister to the left of center. Tomato seeds from experiment P0004-2 were housed inside the other five dome-shaped canisters. The baseplate and canisters were painted white for thermal control. The Velcro pads for attaching the silvered Teflon thermal cover are visible around the perimeter and on top of each of the dome canisters.

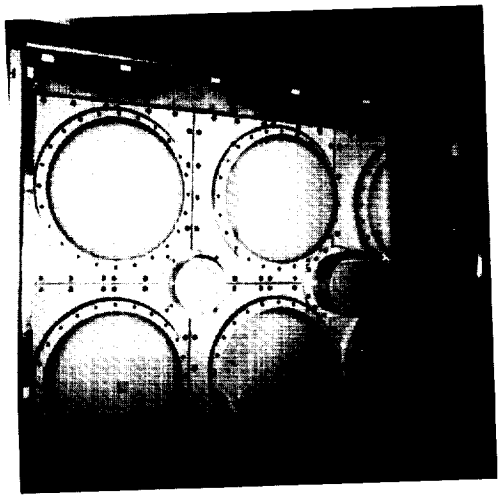

Figure 477
Photo No.: KSC-384C-297.03
Dup. Neg. No.: L84-07124
LISAR No.: EL-1994-00719
Photo Credit: KSC
Photo Date: 1/19/84
Location: KSC SAEF II
Subject: Preflight Survey of Tray F2

***Figure 478 (Preflight).*** This photograph is of the tray after the thermal cover was installed. Thermal control was accomplished by using a thin (5 mil) silvered Teflon thermal cover of material identical to that used for the 16 trays of experiment AO178. Because the thermal cover is highly reflective, it mirrors images, lights, and colors from the area surrounding the tray.

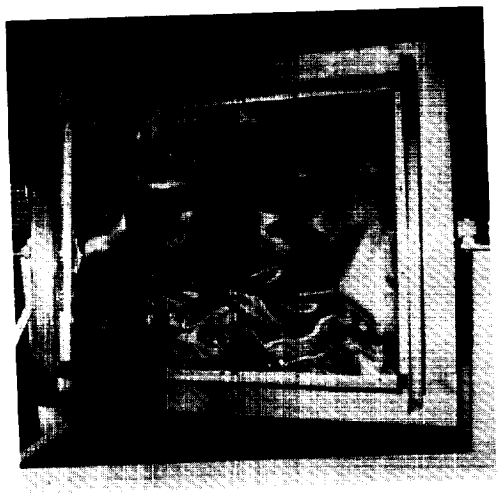

Figure 478
Photo No.: KSC-384C-299.05
Dup. Neg. No.: L84-7150
LISAR No.: EL-1994-00199
Photo Credit: KSC
Photo Date: 1/19/84
Location: KSC SAEF II
Subject: Preflight Survey of Tray F2

***Figure 479 (In Flight).*** The silvered Teflon thermal cover appears to be without physical damage. The three dark spots appearing in a vertical row about a third of a tray width from the right edge of the cover are three Velcro attachment pads. The lighter areas appear diffuse in other photographs.

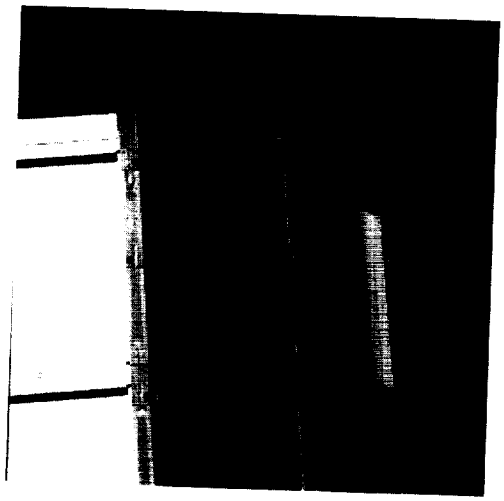

Figure 479
Photo No.: S32-89-023
Dup. Neg. No.: L90-10497
LISAR No.: EL-1994-00132
Photo Credit: JSC
Photo Date: 1/12/90
Location: In Flight
Subject: In-Flight Survey of Tray F2

***Figure 480 (Postflight).*** The silvered Teflon thermal cover is without physical damage. The surroundings are reflected in the surface of the thermal cover. In general, the thermal cover appears specular except for an area in the lower center of the tray, which appears to be somewhat dull. A similar condition was noted on the thermal cover of tray A2 at the other end of the LDEF.

Figure 480
Photo No.: KSC-390C-1465.03
Dup. Neg. No.: L91-1553
LISAR No.: EL-1994-00193
Photo Credit: KSC
Photo Date: 2/23/90
Location: KSC SAEF II
Subject: Postflight Survey of Tray F2

***Figure 481 (Postflight).*** This close-up photograph is of the diffuse area of the thermal cover. Surrounding areas are specular and reflect nearby surroundings.

Figure 481
Photo No.: KSC-390C-1465.05
Dup. Neg. No.: L91-1555
LISAR No.: EL-1994-00389
Photo Credit: KSC
Photo Date: 2/23/90
Location: KSC SAEF II
Subject: Postflight Detail of Diffuse Area of Tray F2

***Figure 482 (Postflight).*** This oblique view of the thermal cover shows the diffuse area of the thermal cover.

Figure 482
Photo No.: KSC-390C-1465.07
Dup. Neg. No.: L91-1557
LISAR No.: EL-1994-00390
Photo Credit: KSC
Photo Date: 2/23/90
Location: KSC SAEF II
Subject: Postflight Detail of Diffuse Area of Tray F2

## Tray F3

Space Debris Impact Experiment (S0001)

NASA LaRC

Trays: A5, A6, A12, B1, B2, B6, B8, B11, C4, C7, D2, D6, E1, E4, E7, E11, F1, F3, F5, F7, F10, F11, G4, G8, and H5

See section entitled "Tray A5" for a typical preflight photographic survey and experiment objective.

No individual in-flight photograph was available.

***Figure 483 (Postflight).*** The pink and greenish-gray tints on the two debris panels are by-products of the chromic anodize coating process and are not attributed to contamination or exposure to the space environment. The light band along the sides and across the bottom of the panels is caused by light reflecting from the tray sidewalls.

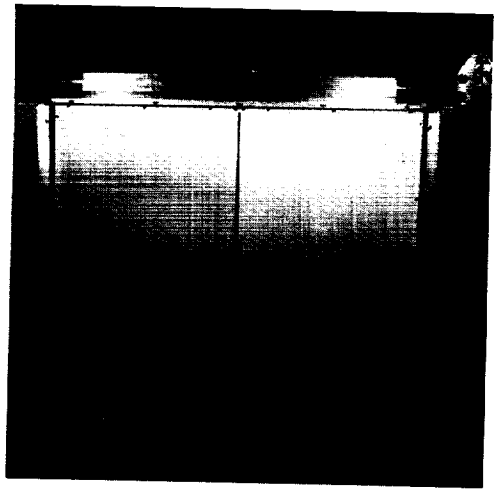

Figure 483
Photo No.: KSC-390C-833.08
Dup. Neg. No.: L90-13367
LISAR No.: EL-1994-00175
Photo Credit: KSC
Photo Date: 2/7/90
Location: KSC SAEF II
Subject: Postflight Survey of Tray F3

## Tray F4

A High-Resolution Study of Ultraheavy Cosmic Ray Nuclei (UHCRE) (AO178)

Dublin Institute for Advanced Studies

ESA at ESTEC

Trays: A2, A4, A10, B5, B7, C5, C6, C8, C11, D1, D5, D7, D11, E2, E10, and F4

See section entitled "Tray D5" and figure 319 for a typical preflight photograph of experiment AO178.

***Figure 484 (In Flight).*** The thermal cover appears to be specular and intact with several small circular areas that appear to be impacts. The cover is more taut than in the prelaunch photograph. The wrinkled spots on the thermal cover are areas where Velcro attachment pads are bonded to the back of the cover. The scalloped effect around the cover edges occurs between the attachment pads. The ground strap is in place and has no visible damage.

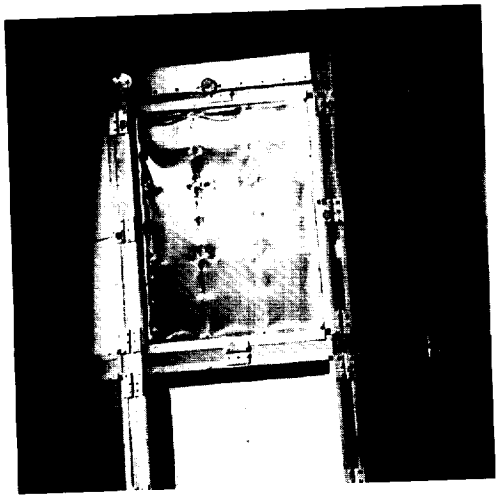

Figure 484
Photo No.: S32-77-092
Dup. Neg. No.: L90-10422
LISAR No.: EL-1994-00002
Photo Credit: JSC
Photo Date: 1/12/90
Location: In Flight
Subject: In-Flight Survey of Tray F4

***Figure 485 (Postflight).*** The thermal cover appears to be specular and intact. Because of lighting, the locations that appeared to be impacts in the in-flight photograph are not apparent. The thermal cover is less taut than in the in-flight photograph. The wrinkled spots on the thermal cover are areas where Velcro attachment pads are bonded to the back of the cover. The scalloped effect around the cover edges occurs between the attachment pads. The ground strap is in place with no visible damage, but it appears darker.

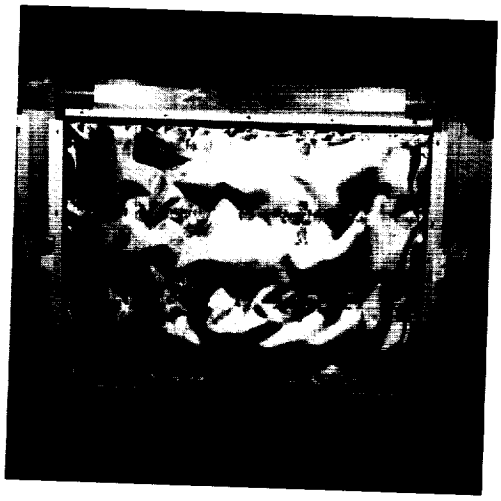

Figure 485
Photo No.: KSC-390C-832.02
Dup. Neg. No.: L90-13349
LISAR No.: EL-1994-00171
Photo Credit: KSC
Photo Date: 2/7/90
Location: KSC SAEF II
Subject: Postflight Survey of Tray F4

***Figure 486 (Postflight).*** This photograph is of the upper left one-sixth of the tray. The thermal cover appears specular with no apparent damage. There seemed to be no opaqueness on the third of the tray. The reflective properties of the uneven surface of the cover result in various light and color patterns. A very few impact or penetration discolorations are visible. The Velcro attachment pads are evident.

Figure 486
Photo No.: KSC-390C-2212.05
Dup. Neg. No.: L91-10848
LISAR No.: EL-1994-00536
Photo Credit: KSC
Photo Date: 3/22/90
Location: KSC SAEF II
Subject: Postflight Detail of Upper Left of Tray F4

***Figure 487 (Postflight).*** This photograph is of the upper center one-sixth of the tray. The thermal cover has no apparent damage; however an area of some opaqueness is beginning to appear. The reflective properties of the uneven surface of the cover result in various light and color patterns. A very few impact or penetration discolorations are visible. The Velcro thermal cover attachment pads are evident.

Figure 487
Photo No.: KSC-390C-2212.06
Dup. Neg. No.: L91-10849
LISAR No.: EL-1994-00537
Photo Credit: KSC
Photo Date: 3/22/90
Location: KSC SAEF II
Subject: Postflight Detail of Upper Center of Tray F4

***Figure 488 (Postflight).*** This photograph is of the upper right one-sixth of the tray. The thermal cover has no apparent damage; however an area of some opaqueness is beginning to appear. The reflective properties of the uneven surface of the cover result in various light and color patterns. A very few impact or penetration discolorations are visible. The Velcro attachment pads are evident.

Figure 488
Photo No.: KSC-390C-2212.07
Dup. Neg. No.: L91-10850
LISAR No.: EL-1994-00538
Photo Credit: KSC
Photo Date: 3/22/90
Location: KSC SAEF II
Subject: Postflight Detail of Upper Right of Tray F4

***Figure 489 (Postflight).*** This photograph is of the lower left one-sixth of the tray. The thermal cover appears specular with no apparent damage. The opaqueness on other parts of the tray is not present here. The reflective properties of the uneven surface of the cover result in various light and color patterns. A very few impact or penetration discolorations are visible. The Velcro attachment pads are evident.

Figure 489
Photo No.: KSC-390C-2212.11
Dup. Neg. No.: L91-10854
LISAR No.: EL-1994-00539
Photo Credit: KSC
Photo Date: 3/22/90
Location: KSC SAEF II
Subject: Postflight Detail of Lower Left of Tray F4

***Figure 490 (Postflight).*** This photograph is of the lower center one-sixth of the tray. The thermal cover has no apparent damage; however an area of some opaqueness is beginning to appear. The reflective properties of the uneven surface of the cover result in various light and color patterns. A very few impact or penetration discolorations are visible. The Velcro attachment pads are evident.

Figure 490
Photo No.: KSC-390C-2212.12
Dup. Neg. No.: L91-10855
LISAR No.: EL-1994-00540
Photo Credit: KSC
Photo Date: 3/22/90
Location: KSC SAEF II
Subject: Postflight Detail of Lower Center of Tray F4

***Figure 491 (Postflight).*** This photograph is of the lower right one-sixth of the tray. The thermal cover appears specular with no apparent damage; however an area of some opaqueness is beginning to appear. The reflective properties of the uneven surface of the cover result in various light and color patterns. A very few impact or penetration discolorations are visible. The Velcro attachment pads are evident.

Figure 491
Photo No.: KSC-390C-2214.02
Dup. Neg. No.: L91-10857
LISAR No.: EL-1994-00541
Photo Credit: KSC
Photo Date: 3/22/90
Location: KSC SAEF II
Subject: Postflight Detail of Lower Right of Tray F4

***Figure 492 (Postflight).*** This oblique view shows the right side of the thermal cover, which appears less specular than the left side.

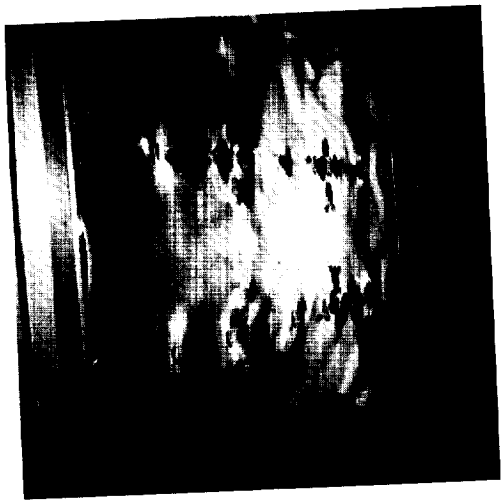

Figure 492
Photo No.: KSC-390C-2214.03
Dup. Neg. No.: L91-10858
LISAR No.: EL-1994-00542
Photo Credit: KSC
Photo Date: 3/22/90
Location: KSC SAEF II
Subject: Postflight Detail of Right Side of Tray F4

## Tray F5

Space Debris Impact Experiment (S0001)

NASA LaRC

Trays: A5, A6, A12, B1, B2, B6, B8, B11, C4, C7, D2, D6, E1, E4, E7, E11, F1, F3, F5, F7, F10, F11, G4, G8, and H5

See section entitled "Tray A5" for a typical preflight photographic survey and experiment objective.

***Figure 493 (In Flight).*** The greenish-gray and pink tints on the two debris panels are by-products of the chromic anodize coating process and are not attributed to contamination or exposure to the space environment. Fingerprints along the center edges of the debris panels indicate improper preflight handling and cleaning.

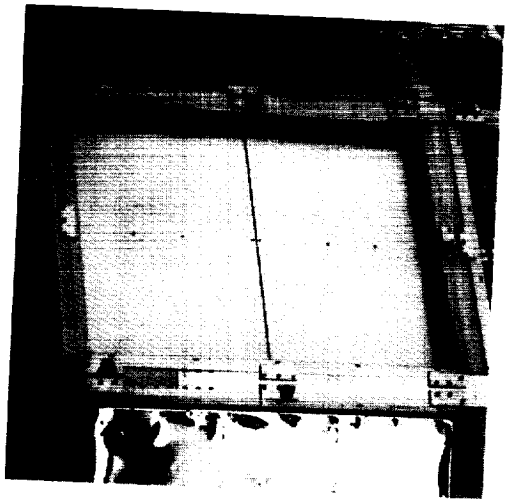

Figure 493
Photo No.: S32-77-045
Dup. Neg. No.: L90-10411
LISAR No.: EL-1994-00677
Photo Credit: JSC
Photo Date: 1/12/90
Location: In Flight
Subject: In-Flight Survey of Tray F5

***Figure 494 (Postflight).*** The greenish-gray and pink tints on the two debris panels are by-products of the chromic anodize coating process and are not attributed to contamination or exposure to the space environment. The fingerprints along the center edges of the debris panels that were observed in the in-flight photograph are still visible. The light band across the bottom of the panels is caused by light reflecting from the tray sidewalls.

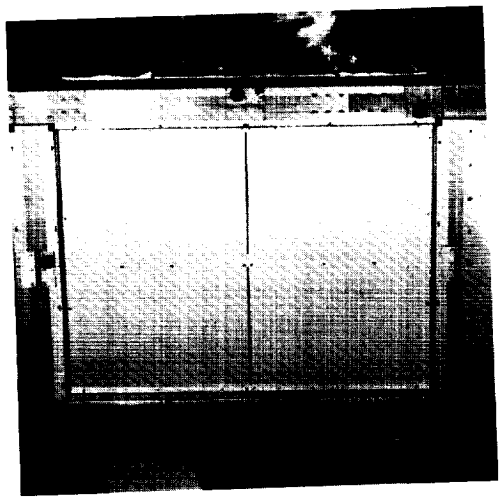

Figure 494
Photo No.: KSC-390C-1035.04
Dup. Neg. No.: L90-13449
LISAR No.: EL-1994-00182
Photo Credit: KSC
Photo Date: 2/9/90
Location: KSC SAEF II
Subject: Postflight Survey of Tray F5

***Figure 498 (Postflight).*** This photograph is of the tray with one of the photographic lights turned off. The brown discoloration is uniform over the tray bottom; however, there is a heavier concentration on the lower left tray wall.

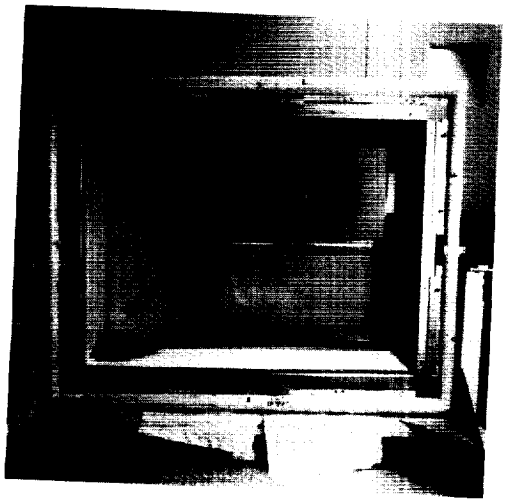

Figure 498
Photo No.: KSC-390C-1563.06
Dup. Neg. No.: L91-11327
LISAR No.: EL-1994-00291
Photo Credit: KSC
Photo Date: 3/5/90
Location: KSC SAEF II
Subject: Postflight Detail of Tray F6

***Figure 499 (Postflight).*** This close-up photograph is of the lower left corner of the tray. There is an area of concentrated brown discoloration on the lower tray wall.

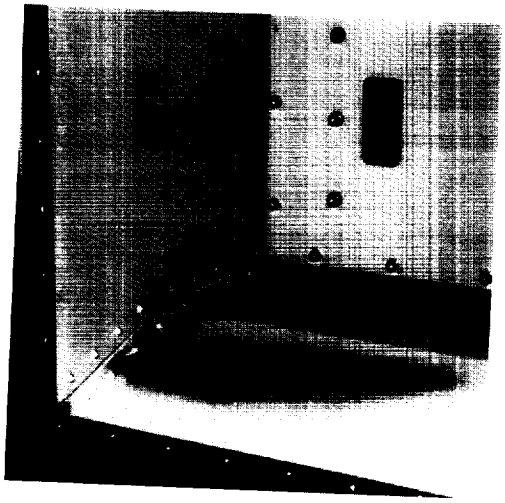

Figure 499
Photo No.: KSC-390C-1564.11
Dup. Neg. No.: L91-11343
LISAR No.: EL-1994-00292
Photo Credit: KSC
Photo Date: 3/5/90
Location: KSC SAEF II
Subject: Postflight Detail of Lower Left of Tray F6

***Figure 500 (Postflight).*** This close-up photograph is of the upper right side of the canister box. The brown discoloration appears uniform, except there is a well-defined discoloration pattern of the canister on the upper tray wall. The cover was installed on the canister housing to protect the space-exposed hardware.

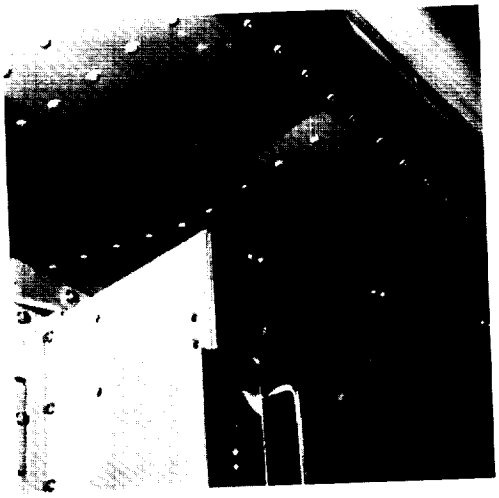

Figure 500
Photo No.: KSC-390C-1565.01
Dup. Neg. No.: L91-11344
LISAR No.: EL-1994-00293
Photo Credit: KSC
Photo Date: 3/5/90
Location: KSC SAEF II
Subject: Postflight Detail of Upper Left of Tray F6

***Figure 501 (Postflight).*** This close-up photograph is of the grid voltage plug area of the tray bottom and left side of the canister box. Note the distinct discoloration pattern of the electrical leads on the canister wall.

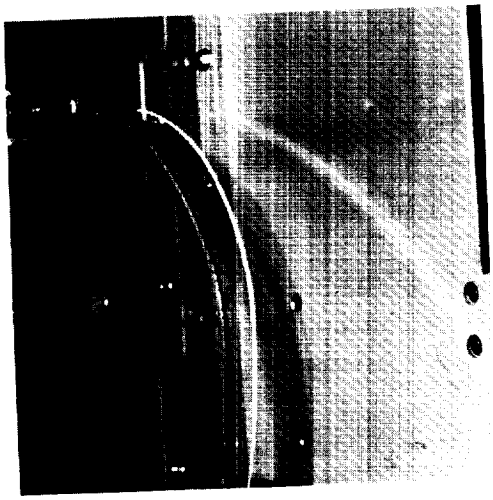

Figure 501
Photo No.: KSC-390C-1565.02
Dup. Neg. No.: L91-11345
LISAR No.: EL-1994-00308
Photo Credit: KSC
Photo Date: 3/5/90
Location: KSC SAEF II
Subject: Postflight Detail of Grid Voltage Plug Area of Tray F6

***Figure 502 (Postflight).*** This close-up photograph is of the lower right corner of the tray and shows the contrast in discoloration of the side walls.

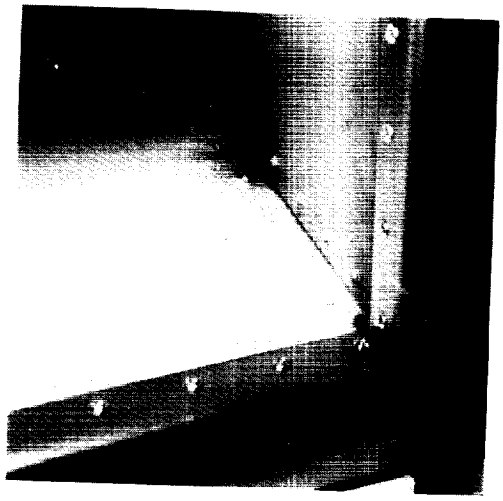

Figure 502
Photo No.: KSC-390C-1565.04
Dup. Neg. No.: L91-11347
LISAR No.: EL-1994-00309
Photo Credit: KSC
Photo Date: 3/5/90
Location: KSC SAEF II
Subject: Postflight Detail of Lower Right Corner of Tray F6

***Figure 503 (Postflight).*** This close-up photograph shows the discoloration pattern of the canister on the tray wall. Also note the faint discoloration pattern of the electrical lead on the canister wall and a shadow resulting from the photographic light below. The cover was installed on the canister housing to protect the space-exposed hardware.

Figure 503
Photo No.: KSC-390C-1565.08
Dup. Neg. No.: L91-11350
LISAR No.: EL-1994-00115
Photo Credit: KSC
Photo Date: 3/5/90
Location: KSC SAEF II
Subject: Postflight Detail of Canister Area of Tray F6

***Figure 504 (Postflight).*** This close-up photograph of the lower left corner of the tray shows the contrast in amount of discoloration.

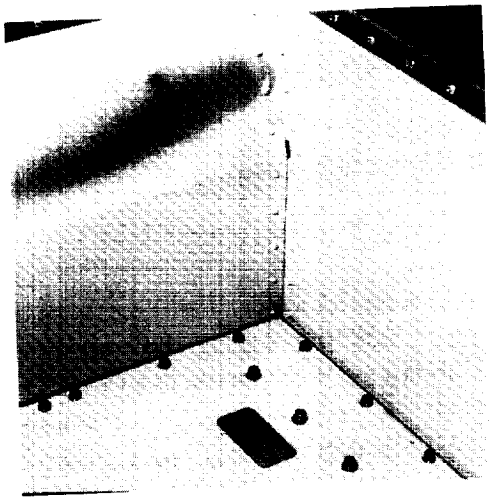

Figure 504
Photo No.: KSC-390C-1565.09
Dup. Neg. No.: L91-11351
LISAR No.: EL-1994-00116
Photo Credit: KSC
Photo Date: 3/5/90
Location: KSC SAEF II
Subject: Postflight Detail of Lower Left Corner of Tray F6

## Tray F7

Space Debris Impact Experiment (S0001)

NASA LaRC

Trays: A5, A6, A12, B1, B2, B6, B8, B11, C4, C7, D2, D6, E1, E4, E7, E11, F1, F3, F5, F7, F10, F11, G4, G8, and H5

See section entitled "Tray A5" for a typical preflight photographic survey and experiment objective.

***Figure 505 (In Flight).*** Note the transition of the tray clamp dot color. The discolorations on the upper tray sidewall appear to be fingerprints from handling during the experiment assembly. A portion of the pink and greenish-gray tint on the two debris panels is a by-product of the chromic anodize coating process; however, a part of the intensity can be attributed to reflections of the blue sky. The horizontal streaks on the right debris panel and the vertical streaks on the left debris panel are by-products of chromic anodizing that have been enhanced by the blue reflection. The light band along the vertical edge of the debris panel is a reflection from the tray sidewall.

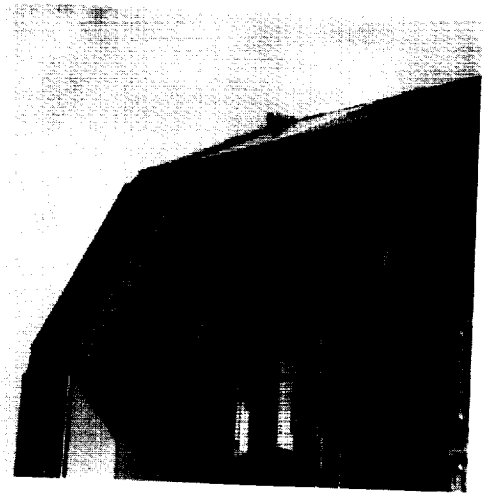

Figure 505
Photo No.: S32-82-026
Dup. Neg. No.: L90-10459
LISAR No.: EL-1994-00039
Photo Credit: JSC
Photo Date: 1/12/90
Location: In Flight
Subject: In-Flight Survey of Tray F7

***Figure 506 (Postflight).*** The pink and greenish-gray tints on the two debris panels are by-products of the chromic anodize coating process and are not attributed to contamination or exposure to the space environment. The streaks on the debris panels in the in-flight photographs are almost invisible because the reflection of the sky is not present. The light band along the sides and across the bottom of the panels is caused by light reflecting from the tray sidewalls.

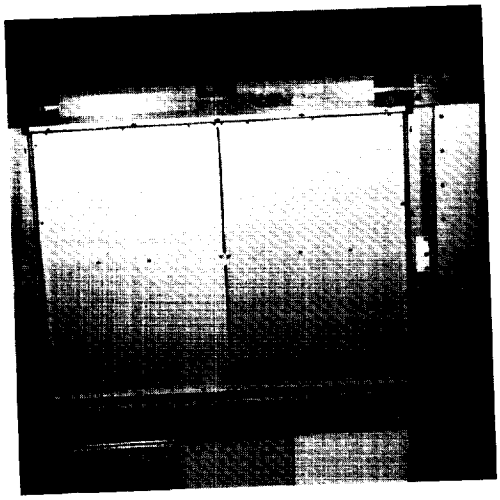

Figure 506
Photo No.: KSC-390C-1032.02
Dup. Neg. No.: L90-13424
LISAR No.: EL-1994-00177
Photo Credit: KSC
Photo Date: 2/9/90
Location: KSC SAEF II
Subject: Postflight Survey of Tray F7

## Tray F8

Space Environment Effects on Fiber Optics Systems (M0004)

Air Force Weapons Laboratory

Tray: F8

The objectives of this experiment were to assess the survivability of a hardened fiber optic link design for application in future spacecraft systems and to collect, analyze, and document the effects of space environmental conditions on link performance.

***Figure 507 (Preflight).*** This experiment included four active linked fiber optic cables: one black, one royal blue, one yellow, and one light tan. Each link was configured in a planar, helix coil that was attached to thermally isolated mounting plates with black anodized aluminum clips cushioned with silicone-rubber spacers. The yellow and the light tan cables were configured into one coil, while the black and the blue were configured into individual coils. The three mounting plates were coated with off-white thermal control paint. The large cover plate was coated with Chemglaze II A-276 white paint and the smaller cover plate was coated with IITRI S13G-LO white paint to meet thermal control requirements.

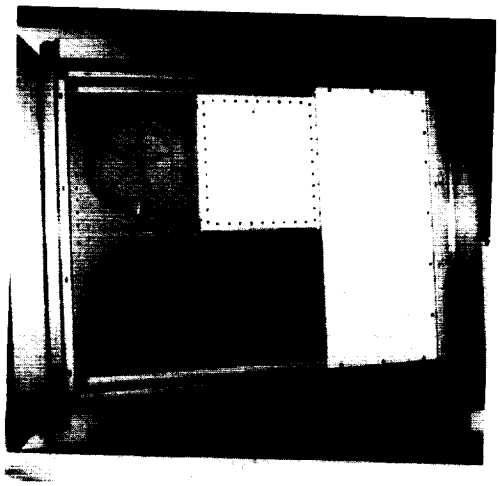

Figure 507
Photo No.: KSC-384C-293.07
Dup. Neg. No.: L84-7104
LISAR No.: EL-1994-00383
Photo Credit: KSC
Photo Date: 1/19/84
Location: KSC SAEF II
Subject: Preflight Survey of Tray F8

***Figure 508 (In Flight).*** The coils have changed color. The upper right coil, originally glossy black, now appears to be dark brown. The lower right coil, originally a glossy royal blue, now appears to be navy blue. The two 20-m coils of linked fiber optic cables in the lower left have more extensive color changes. The exterior cable that was originally yellow now appears to be slate gray and the interior cable that was light tan appears to be brown.

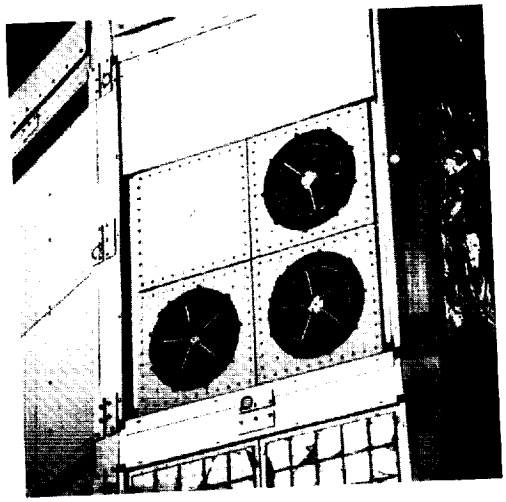

Figure 508
Photo No.: S32-76-020
Dup. Neg. No.: L90-10379
LISAR No.: EL-1994-00664
Photo Credit: JSC
Photo Date: 1/12/90
Location: In Flight
Subject: In-Flight Survey of Tray F8

***Figure 509 (Postflight).*** Colors of all three exposed coils of fiber optic cables have changed significantly. The lower right cable, which was originally glossy black, is now dark brown. The lower left cable, which was originally glossy royal blue, is now navy blue. The upper left cable, which was originally yellow and that was slate gray in flight, is now light gray. The cable that was brown in flight is now a lighter brown. The Chemglaze white paint on the large cover plate has maintained the prelaunch color, but the IITRI S13G-LO white paint on the small cover plate has changed to a uniform light tan.

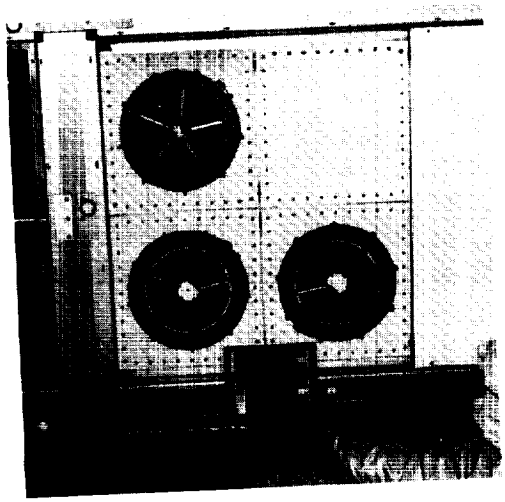

Figure 509
Photo No.: KSC-390C-1145.02
Dup. Neg. No.: L91-15071
LISAR No.: EL-1994-00191
Photo Credit: KSC
Photo Date: 2/18/90
Location: KSC SAEF II
Subject: Postflight Survey of Tray F8

***Figure 510 (Postflight).*** This photograph is of the lower left coil of fiber optic cable. The cable was originally a glossy royal blue, but it is now a darker, duller navy blue. The color of the silicone-rubber spacers under the coil attachment clips has changed from clear to brown. The spacers appear to have discolored the cables. Brown discolorations have appeared at the lower left corner of the tray.

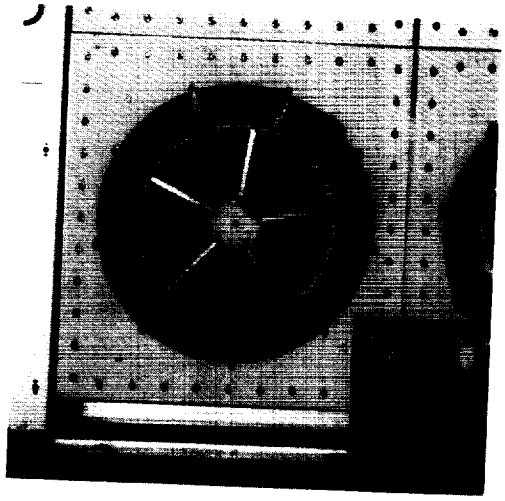

Figure 510
Photo No.: KSC-390C-1145.03
Dup. Neg. No.: L91-15072
LISAR No.: EL-1994-00306
Photo Credit: KSC
Photo Date: 2/18/90
Location: KSC SAEF II
Subject: Postflight Detail of Lower Left Fiber Optic Coil of Tray F8

***Figure 511 (Postflight).*** This photograph is of the lower right coil of fiber optic cable. The cable that was originally glossy black is now dark brown. The color of the silicone-rubber spacers under the coil attachment clips has changed from clear to brown. The spacers have discolored the cables. There is some discoloration near the lower right corner of the coil mounting plate

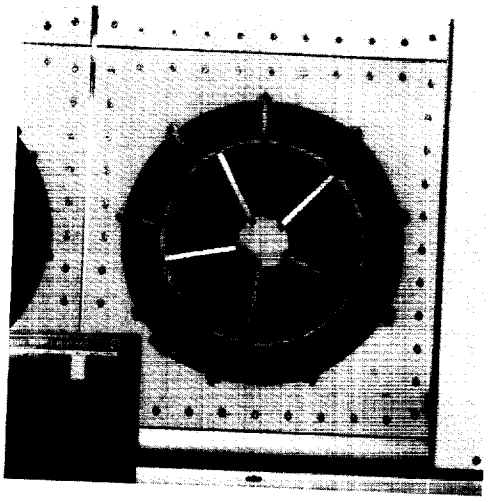

Figure 511
Photo No.: KSC-390C-1145.04
Dup. Neg. No.: L91-15073
LISAR No.: EL-1994-00307
Photo Credit: KSC
Photo Date: 2/18/90
Location: KSC SAEF II
Subject: Postflight Detail of Lower Right Fiber Optic Coil of Tray F8

***Figure 512 (Postflight).*** This photograph is of the two 20-m coils of fiber optic cables in the upper left part of the tray. These coils have more extensive color changes than the other coils. The cable that was originally yellow and that was slate gray in the in-flight photograph, is now a light gray. The cable that was brown in the in-flight photograph, now is a lighter brown. The color of the silicone-rubber spacers under the coil attachment clips has changed from clear to brown. The spacers appear to have discolored the cables. There is also discoloration on the mounting plate just above the coils and on the tray at the upper left corner.

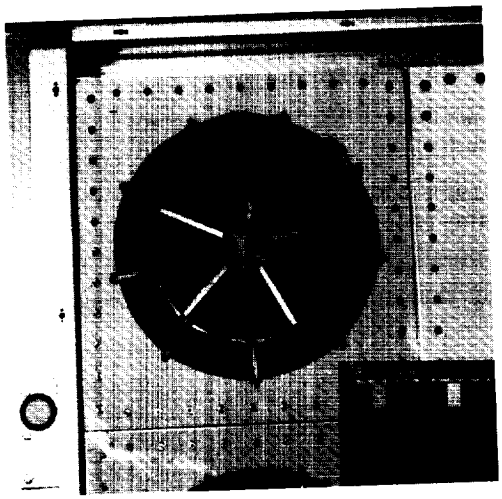

Figure 512
Photo No.: KSC-390C-1145.05
Dup. Neg. No.: L91-15074
LISAR No.: EL-1994-00322
Photo Credit: KSC
Photo Date: 2/18/90
Location: KSC SAEF II
Subject: Postflight Detail of Fiber Optics Links in Upper Left of Tray F8

## Tray F9

Cascade Variable-Conductance Heat Pipe (CVCHP) (AO076)

McDonnell Douglas Astronautics Company

Tray: F9

The objective of this experiment was to verify the capability of a cascade variable-conductance heat pipe system to provide precise temperature control without other power sources.

***Figure 513 (Preflight).*** The experiment includes two variable-conductance heat pipes connected in series, a black chrome solar collector panel, a silvered Teflon radiator panel, a power source to support six thermistor-type temperature monitoring sensors, and two actuation valves. The solar collector is in the lower right of the tray and the radiator panel is in the lower left corner. The outside of experiment AO076, except the collector and radiator panels, was covered with a multilayer insulation blanket with an outer layer of 0.076-mm-thick Kapton film that was coated with vapor-deposited aluminum on one side. Two patches of thin-film materials, part of an atomic oxygen coatings investigation (experiment S1001), were attached to the cover of the external thermal blanket with Kapton tape.

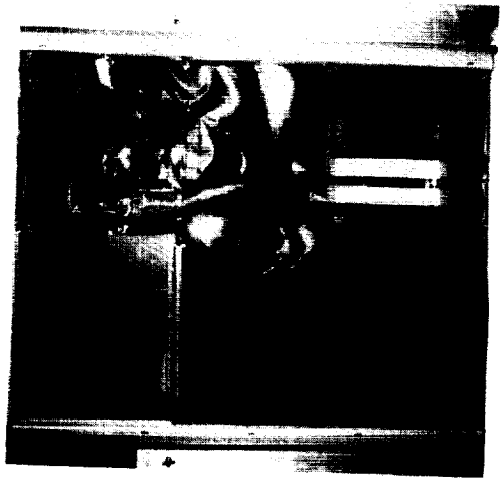

Figure 513
Photo No.: KSC-383C-4418.02
Dup. Neg. No.: L84-7310
LISAR No.: EL-1994-00302
Photo Credit: KSC
Photo Date: 12/8/83
Location: KSC SAEF II
Subject: Preflight Survey of Tray F9

***Figure 514 (In Flight).*** Aluminum particles from the degraded thermal blanket of experiment AO076 are visible on the upper structure intercostal. There is a line of dark discoloration on this intercostal that was adjacent to the edge of the space end thermal panel. An area underneath the edge of the thermal panel allowed venting of the LDEF interior. The external materials of experiment AO076 have changed significantly. The Kapton film on the thermal blanket appears to be completely eroded, except under the buttons that were used to secure the blanket. The erosion left only a very thin coating of vapor-deposited aluminum as a cover. Aluminum coating residue has covered a portion of the black chrome solar collector and also areas of the upper and lower flanges of the trays. The shadow on the tray lower flange indicates that the aluminum extends several inches beyond the tray. One of two thin-film atomic oxygen experiment patches is gone and the other does not appear to be securely attached. The layer of Kapton tape over the thin-film strips appears to be eroded with only the adhesive remaining. The remaining atomic oxygen experiment materials have changed color and most appear to be severely degraded. The silvered Teflon coating of the radiator panel appears diffuse with a light brown discoloration over most of the surface. The black spots on the radiator panel appear to be impact craters where debris penetrated the Teflon material and exposed the silver beneath to atomic oxygen flux. Particles of the degraded thermal blanket material appear to be adhered to the surface of the radiator panel.

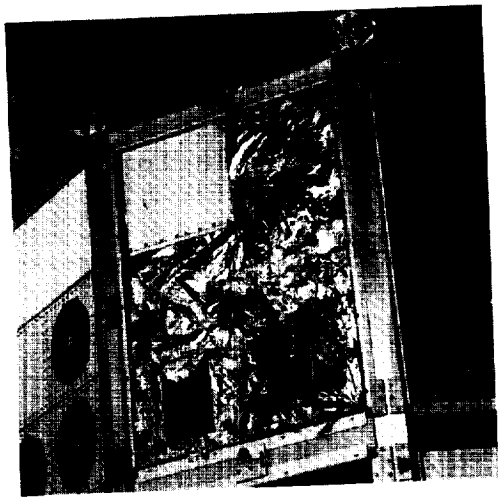

Figure 514
Photo No.: S32-78-087
Dup. Neg. No.: L90-10448
LISAR No.: EL-1994-00020
Photo Credit: JSC
Photo Date: 1/12/90
Location: In Flight
Subject: In-Flight Survey of Tray F9

***Figure 515 (Postflight).*** The LDEF structure with the intercostal on the right has a dark brown discoloration that is adjacent to the edge of the space end thermal panel. An area underneath the edge of the thermal panel allows venting of the LDEF interior. Aluminum pieces of the degraded experiment AO076 thermal cover that were lodged in the vent in the in-flight photograph are gone. The external surface of the experiment AO076 has changed dramatically from that observed in the in-flight photograph. The thin coating of vapor-deposited aluminum, which was left after the Kapton film eroded, is essentially gone; only fragments of the coating are left near the edges of the thermal blanket. Pieces of Dacron mesh (bridal veil) material, which was used to separate the thermal cover from the thermal blanket and between sheets of aluminized Kapton film in the thermal blanket, are visible along the edges of the blanket and near the buttons that were used to secure the blanket. A large fragment of the Dacron mesh is folded over the left side of the radiator panel. The large discoloration on the right side of the black chrome solar collector panel is approximately the same shape as the aluminum coating that covered the area in the in-flight photograph. The orientation of the remaining thin-film atomic oxygen experiment patch indicates that the patch is attached to the Dacron mesh and that the attachment is very fragile. The layer of Kapton tape that covered the ends of the thin-film strips appears to have eroded, thus exposing the adhesive. The remaining materials of the atomic oxygen experiment have changed color; most are severely degraded. The silvered Teflon coating of the radiator panel appears diffuse with a light brown discoloration over most of the surface. The white, evenly spaced, discolorations along the horizontal centerline and along the edges of the panel appear to be above countersunk flat head screws used to assemble the experiment. The black spots on the radiator panel appear to be impact craters that penetrated the Teflon material and exposed the silver beneath to atomic oxygen flux. Particles of the degraded thermal blanket material, which appeared to adhere to the surface of the radiator panel in the in-flight photograph, are gone.

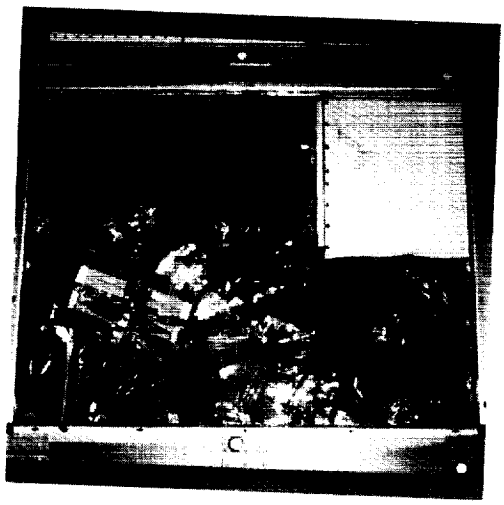

Figure 515
Photo No.: L90-1826
LISAR No.: EL-1994-00354
Photo Credit: LaRC
Photo Date: 3/12/90
Location: KSC SAEF II
Subject: Postflight View of Tray F9

***Figure 516 (Postflight).*** This photograph is of the tray after the atomic oxygen experiment was removed.

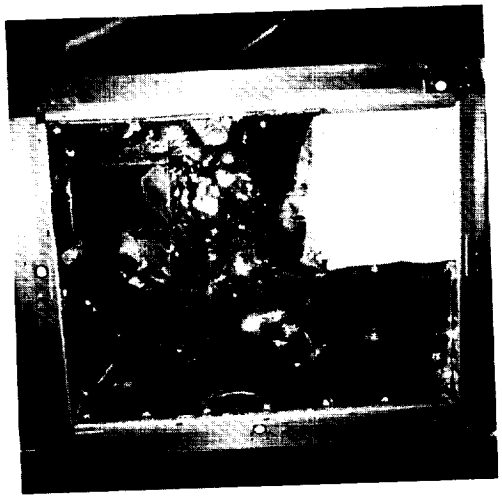

Figure 516
Photo. No.: KSC-390C-2157.03
Dup. Neg. No.: L91-11449
LISAR No.: EL-1994-00519
Photo Credit: KSC
Photo Date: 3/21/90
Location: KSA SAEF II
Subject: Postflight Detail of Tray F9

***Figure 517 (Postflight).*** This photograph is of the upper left one-sixth of the tray. The thin coating of vapor-deposited aluminum, left after the Kapton film eroded, is essentially gone and only fragments of the thermal blanket remain. Pieces of Dacron mesh material are visible along the edges of the blanket and near the buttons that were used to secure the blanket. The large area of discoloration on the right side of the black chrome solar collector panel appears to be approximately the same shape as the aluminum coating that covered the area in the in-flight photograph.

Figure 517
Photo No.: KSC-390C-2157.04
Dup. Neg. No.: L91-11450
LISAR No.: EL-1994-00520
Photo Credit: KSC
Photo Date: 3/21/90
Location: KSC SAEF II
Subject: Postflight Detail of Upper Left of Tray F9

***Figure 518 (Postflight).*** This photograph is of the upper center one-sixth of the tray. The thin coating of vapor-deposited aluminum, left after the Kapton film eroded, is essentially gone and only fragments of the thermal blanket remain. Pieces of Dacron mesh are visible along the edges of the blanket and near the buttons that were used to secure the blanket. A large fragment of the Dacron mesh is folded over the left side of the radiator panel.

Figure 518
Photo No.: KSC-390C-2157.05
Dup. Neg. No.: L91-11451
LISAR No.: EL-1994-00521
Photo Credit: KSC
Photo Date: 3/21/90
Location: KSC SAEF II
Subject: Postflight Detail of Upper Center of Tray F9

***Figure 519 (Postflight).*** This photograph is of the upper right one-sixth of the tray. The thin coating of vapor-deposited aluminum, left after the Kapton film eroded, is essentially gone and only fragments of the thermal blanket remain. Small discolorations that were caused by impacts are visible on the silvered Teflon film surface of the radiator. Pieces of Dacron mesh are visible. The fragment that covered the left side of the radiator panel has moved to the left.

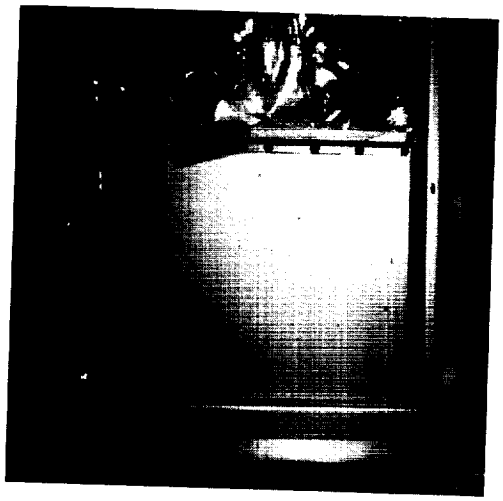

Figure 519
Photo No.: KSC-390C-2157.06
Dup. Neg. No.: L91-11452
LISAR No.: EL-1994-00522
Photo Credit: KSC
Photo Date: 3/21/90
Location: KSC SAEF II
Subject: Postflight Detail of Upper Right of Tray F9

***Figure 520 (Postflight).*** This photograph is of the lower left one-sixth of the tray. The thin coating of vapor-deposited aluminum, left after the Kapton film eroded, is essentially gone and only fragments of the thermal blanket remain. Pieces of Dacron mesh are visible along the edges of the blanket and near the buttons that were used to secure the blanket.

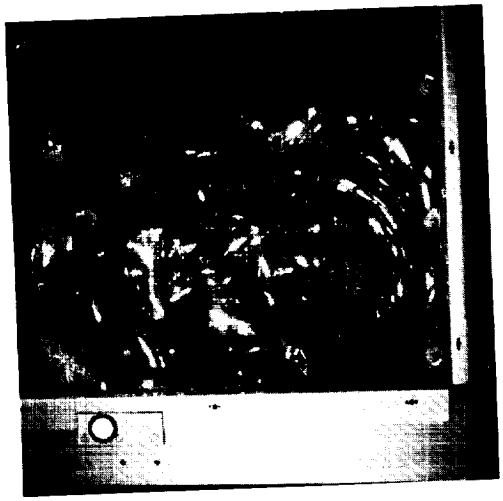

Figure 520
Photo No.: KSC-390C-2157.07
Dup. Neg. No.: L91-11453
LISAR No.: EL-1994-00523
Photo Credit: KSC
Photo Date: 3/21/90
Location: KSC SAEF II
Subject: Postflight Detail of Lower Left of Tray F9

***Figure 521 (Postflight).*** This photograph is of the lower center one-sixth of the tray. The thin coating of vapor-deposited aluminum, left after the Kapton film eroded, is essentially gone and only fragments of the thermal blanket remain. Pieces of Dacron mesh are visible along the edges of the blanket and near the buttons that were used to secure the blanket.

Figure 521
Photo No.: KSC-390C-2157.08
Dup. Neg. No.: L91-11454
LISAR No.: EL-1994-00524
Photo Credit: KSC
Photo Date: 3/21/90
Location: KSC SAEF II
Subject: Postflight Detail of Lower Center of Tray F9

***Figure 522 (Postflight).*** This photograph is of the lower right one-sixth of the tray. The thin coating of vapor-deposited aluminum, which was left after the Kapton film eroded, is essentially gone and only fragments of the thermal blanket remain. Pieces of Dacron mesh are visible along the edges of the blanket and near the buttons that were used to secure the blanket. Note the dark brown discoloration at the edge of the thermal panel at the right.

Figure 522
Photo No.: KSC-390C-2157.09
Dup. Neg. No.: L91-11455
LISAR No.: EL-1994-00525
Photo Credit: KSC
Photo Date: 3/21/90
Location: KSC SAEF II
Subject: Postflight Detail of Lower Right of Tray F9

## Tray F10

Space Debris Impact Experiment (S0001)

NASA LaRC

Trays: A5, A6, A12, B1, B2, B6, B8, B11, C4, C7, D2, D6, E1, E4, E7, E11, F1, F3, F5, F7, F10, F11, G4, G8, and H5

See section entitled "Tray A5" for a typical preflight photographic survey and experiment objective.

No in-flight photograph was available.

***Figure 523 (Postflight).*** The green tint on the two debris panels is a by-product of the chromic anodize coating process and is not attributed to contamination or exposure to the space environment. A light irregular vertical streak is on the right debris panel. The light band across the top and bottom edges of the panels is caused by light reflecting from the tray sidewalls.

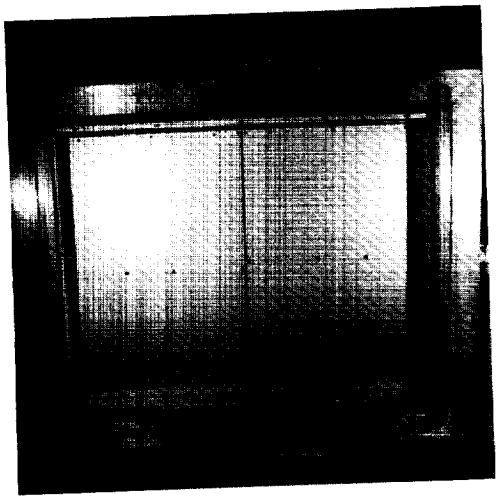

Figure 523
Photo No.: KSC-390C-1655.07
Dup. Neg. No.: L91-11492
LISAR No.: EL-1994-00262
Photo Credit: KSC
Photo Date: 3/6/90
Location: KSC SAEF II
Subject: Postflight Survey of Tray F10

## Tray F11

Space Debris Impact Experiment (S0001)

NASA LaRC

Trays: A5, A6, A12, B1, B2, B6, B8, B11, C4, C7, D2, D6, E1, E4, E7, E11, F1, F3, F5, F7, F10, F11, G4, G8, and H5

See section entitled "Tray A5" for a typical preflight photographic survey and experiment objective.

***Figure 524 (In Flight).*** A portion of the greenish-gray tint on the two debris panels is a by-product of the chromic anodize coating process; however, some blue can be attributed to reflection of the sky. The vertical streaks on the right debris panel are by-products of chromic anodizing that have been enhanced by the blue reflection. The brown stains along the top edge of the right debris panel appear to be fingerprints from prelaunch handling.

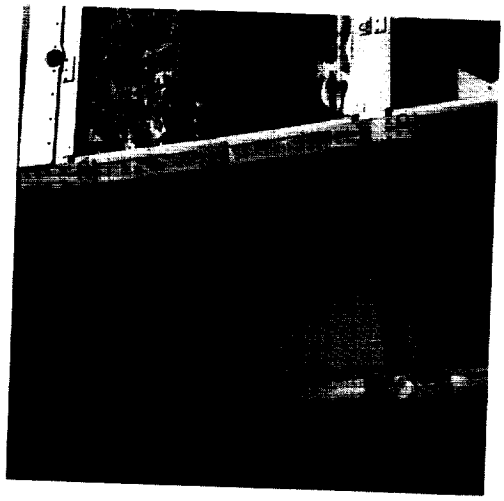

Figure 524
Photo No.: S32-78-069
Dup. Neg. No.: L90-10441
LISAR No.: EL-1994-00015
Photo Credit: JSC
Photo Date: 1/12/90
Location: In Flight
Subject: In-Flight Survey of Tray F11

***Figure 525 (Postflight).*** The pink and greenish-gray tints on the two debris panels are by-products of the chromic anodize coating process and are not attributed to contamination or exposure to the space environment. Debris from other experiments that degraded during the mission is visible on the lower experiment tray sidewall at the intersection with the right tray sidewall. A larger piece is located in the upper right corner on the right debris panel. Other experiment debris, which are visible as dark specks, are at the intersection of the debris panel outer edges and the tray sidewalls. The light band along the sides and across the bottom of the panels is caused by light reflecting from the tray sidewalls.

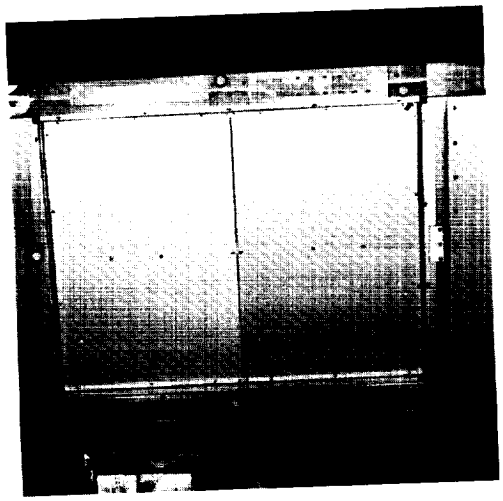

Figure 525
Photo No.: KSC-390C-1028.03
Dup. Neg. No.: L90-13377
LISAR No.: EL-1994-00139
Photo Credit: KSC
Photo Date: 2/9/90
Location: KSC SAEF II
Subject: Postflight Survey of Tray F11

## Tray F12

Low-Temperature Heat Pipe Experiment Package for LDEF (HEPP) (S1001)

NASA GSFC

NASA ARC

Trays: F12 and H1

The objectives of this experiment were to determine start-up performance for conventional and diode low-temperature heat pipes in zero gravity, to evaluate heat pipe performance in zero gravity for an extended period of time, to determine transport capability of each heat pipe in zero gravity, and to determine diode operation, such as forward conductance, turndown ratio, and transient behavior.

***Figure 526 (Preflight).*** The electrical cables in the lower part of the photograph are non-flight cables that connect the experiment S1001 with the ground support test equipment. The radiator and radiator shield panels located in the left half of the tray were covered with silvered Teflon tape to provide the desired optical properties. The outside of the experiment S1001, except the radiator shield panels and the radiator, was covered with a multilayer insulation blanket that had an outer Kapton film layer coated with vapor-deposited aluminum on one side. Two patches of thin-film materials, part of an atomic oxygen experiment that consisted of 5 patches of 13 samples each, which were located at 3 different places on the LDEF (trays F9, F12, and H1), were attached to the cover of the external thermal blanket with Kapton tape.

Figure 526
Photo No.: KSC-383C-4425.08
Dup. Neg.: None
LISAR No.: EL-1994-00319
Photo Credit: KSC
Photo Date: 12/07/83
Location: KSC SAEF II
Subject: Preflight Survey of Tray F12

***Figure 527 (In Flight).*** The radiator and the radiator shields appear deep blue, which is apparently caused by the lighting and the reflecting surface. The upper and lower radiator side shields are discolored by a brown stain that is visible through the deep blue. The Teflon tape used to provide continuity between the side shield and end shield appears to be only secured at the outer edges. The tape and the areas initially covered by the tape appear discolored. The external thermal control blanket appears to be in good condition; however, the lower patch of the atomic oxygen experiment materials has many severely degraded samples. Several of the materials have sections that have eroded away and remain attached at only one end. Others are to be completely gone. The materials in the upper patch appear to have survived better, but they are wrinkled and have distorted shapes.

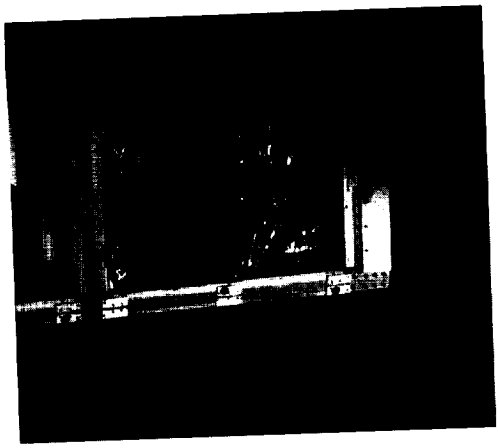

Figure 527
Photo No.: S32-78-036
Dup. Neg. No.: L90-10432
LISAR No.: EL-1994-00008
Photo Credit: JSC
Photo Date: 1/12/90
Location: In Flight
Subject: In-Flight Survey of Tray F12

***Figure 528 (Postflight).*** The upper and lower radiator shields have fine vertical marks that may be cracks or abrasions on the surfaces and are discolored by a brown stain. A darker brown stain appears at the intersection of the end shield sections and in the lower left corner where the silvered Teflon tape, which is hanging over the LDEF structure, has pulled away. The area initially covered by the tape appears clean and is outlined by a vertical line of discolored material. The external thermal control blanket has cracks and tears near the intersection with the radiator; it appears more fragile than in the prelaunch photograph. The lower patch of atomic oxygen experiment materials has many severely degraded samples. Several of the materials have sections eroded away and remain attached at only one end. Other materials are completely gone or have only fragments that remain. The materials in the upper patch have survived better, but are eroded, wrinkled, and have distorted shapes. Discolorations that appear to be pieces of Kapton tape lie horizontally across the lower third of the upper patch of materials. Another piece of Kapton tape lies horizontally across the center of the lower patch of material samples.

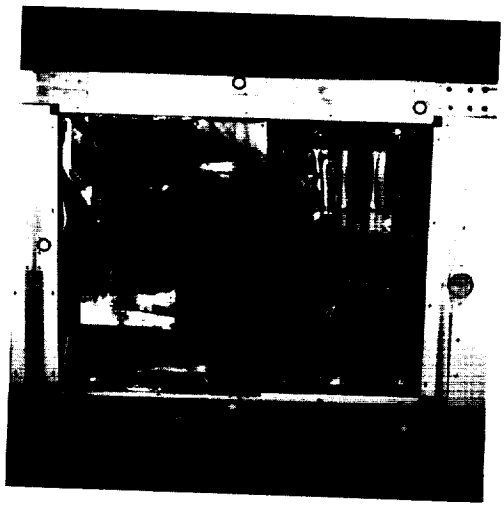

Figure 528
Photo No.: KSC-390C-1069.08
Dup. Neg. No.: L90-13488
LISAR No.: EL-1994-00190
Photo Credit: KSC
Photo Date: 2/8/90
Location: KSC SAEF II
Subject: Postflight Survey of Tray F12

## Tray G2

Free-Flyer Biostack Experiment (AO015)

Institute for Flight Medicine, DFVLR

Trays: C2 and G2

This experiment investigated the biological effect of cosmic radiation and microgravity on biomolecules, cysts, spores, and plant seeds.

***Figure 529 (Preflight).*** Experiment AO015 consists of 12 hermetically sealed aluminum housings that were coated with Chemglaze II A-276 white paint. The canisters contain the test specimens and are mounted on an anodized aluminum baseplate. Two housings have windows that were covered with Kapton H foil, which provides low-radiation absorption and a light filter. Two others have an anodized aluminum spherical cover with an open area that limits incoming radiation from the albedo of the Earth.

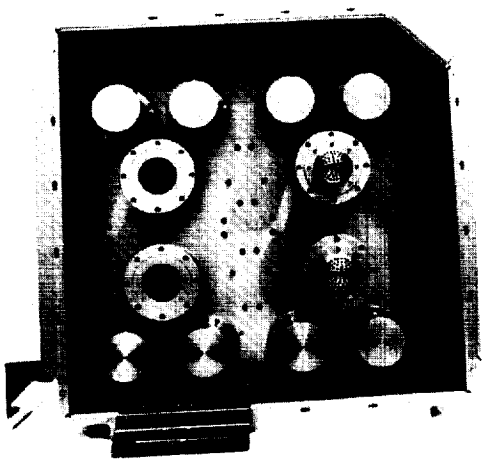

Figure 529
Photo No.: KSC-384C-14.09
Dup. Neg. No.: L84-7011
LISAR NO.: EL-1994-00331
Photo Credit: KSC
Photo Date: 1/9/84
Location: KSC SAEF II
Subject: Preflight Survey of Tray G2

***Figure 530 (In Flight).*** The frame structure is discolored in locations that are adjacent to the edge of the black thermal panels. There is a reflection of canisters in the right and lower tray side walls. The Biostack Experiment AO015 appears to have survived with all hardware in place. The exposed Kapton H foil that covered windows in two detector housings is deformed because of positive internal pressure, but remains intact.

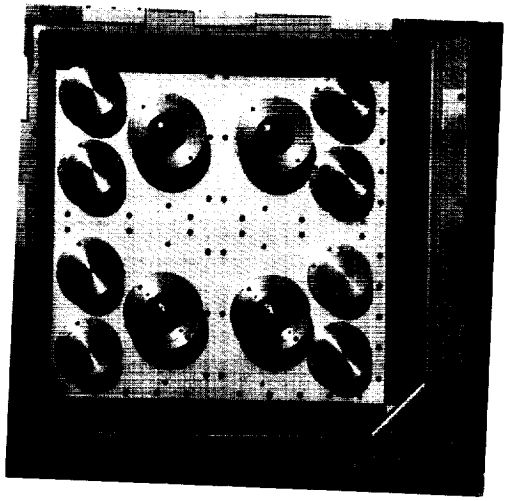

Figure 530
Photo No.: S32-76-068
Dup. Neg. No.: L90-10392
LISAR NO.: EL-1994-00669
Photo Credit: JSC
Photo Date: 1/12/90
Location: In Flight
Subject: In-Flight Survey of Tray G2

***Figure 531 (Postflight).*** The experiment appears to have survived the extended mission with no visible damage. The experiment housings are intact and all hardware is securely in place. The detector housings appear to have a stain that is similar to that on the tray hardware. The Kapton H foil that covered windows in two detector housings does not appear to have been damaged during the extended mission. The perforated dome on two of the detector housings has a slight tan discoloration, but there is no indication of damage.

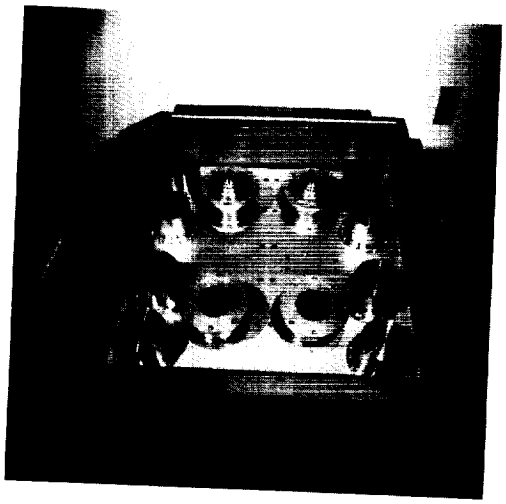

Figure 531
Photo No.: KSC-390C-1938.09
Dup. Neg. No.: L91-11607
LISAR NO.: EL-1994-00282
Photo Credit: KSC
Photo Date: 3/14/90
Location: KSC SAEF II
Subject: Postflight Survey of Tray G2

***Figure 532 (Postflight).*** This photograph is of the upper left one-fourth of the tray. The experiment housings are intact and all hardware is securely in place. The detector housings appear to have a light stain.

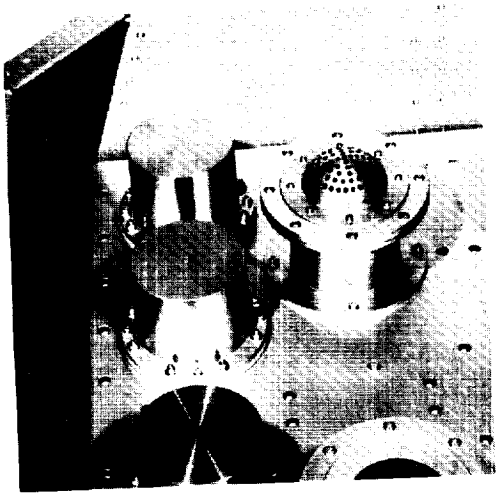

Figure 532
Photo No. KSC-390C-1938.10
Dup. Neg. No.: L91-11608
LISAR NO.: EL-1994-00437
Photo Credit: KSC
Photo Date: 3/14/90
Location: KSC SAEF II
Subject: Postflight Detail of Upper Left of Tray G2

***Figure 533 (Postflight).*** This photograph is of the lower left one-fourth of the tray. The experiment housings are intact and all hardware is securely in place. The detector housings appear to have a light stain.

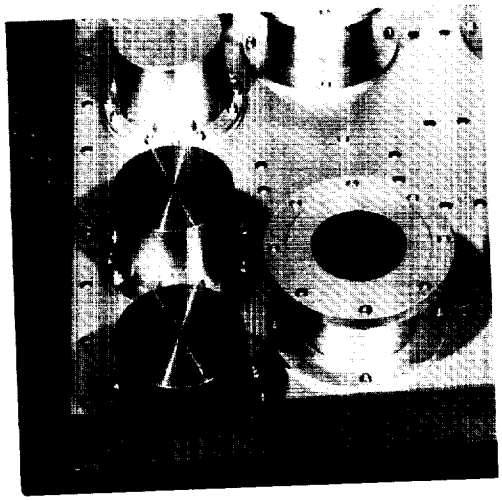

Figure 533
Photo No. KSC-390C-1938.11
Dup. Neg. No.: L91-11609
LISAR NO.: EL-1994-00438
Photo Credit: KSC
Photo Date: 3/14/90
Location: KSC SAEF II
Subject: Postflight Detail of Lower Left of Tray G2

***Figure 534 (Postflight).*** This photograph is of the lower right one-fourth of the tray. The experiment housings are intact and all hardware is securely in place. The detector housings appear to have a light stain.

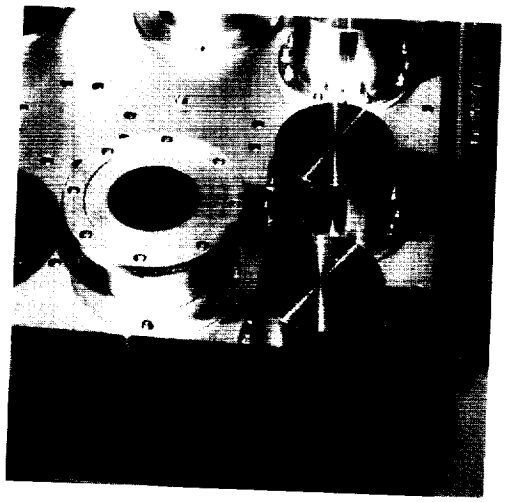

Figure 534
Photo No. KSC-390C-1938.12
Dup. Neg. No.: L91-11610
LISAR NO.: EL-1994-00439
Photo Credit: KSC
Photo Date: 3/14/90
Location: KSC SAEF II
Subject: Postflight Detail of Lower Right of Tray G2

***Figure 535 (Postflight).*** This photograph is of the upper right one-fourth of the tray. The experiment housings are intact and all hardware is securely in place. The detector housings appear to have a light stain.

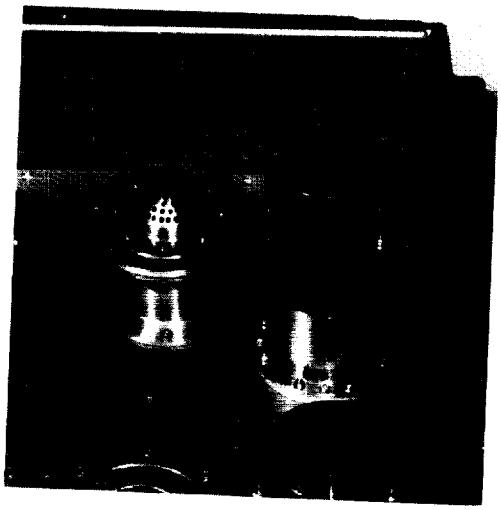

Figure 535
Photo No. KSC-390C-1939.01
Dup. Neg. No.: L91-11611
LISAR NO.: EL-1994-00440
Photo Credit: KSC
Photo Date: 3/14/90
Location: KSC SAEF II
Subject: Postflight Detail of Upper Right of Tray G2

## Tray G4

Space Debris Impact Experiment (S0001)

NASA LaRC

Trays: A5, A6, A12, B1, B2, B6, B8, B11, C4, C7, D2, D6, E1, E4, E7, E11, F1, F3, F5, F7, F10, F11, G4, G8, and H5

See section entitled "Tray A5" for experiment objective. No individual preflight or in-flight photograph was available.

***Figure 536 (Postflight).*** The light pink tint of the debris panel is a by-product of the chromic anodize coating process and is not attributed to contamination or exposure to the space environment. A brown stain is located in the lower right corner of the tray.

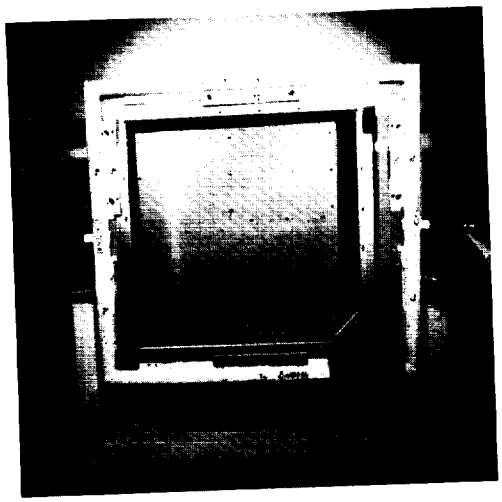

Figure 536
Photo No.: KSC-390C-2309.11
Dup. Neg. No.: L91-11626
LISAR NO.: EL-1994-00314
Photo Credit: KSC
Photo Date: 3/26/90
Location: KSC SAEF II
Subject: Postflight Survey of Tray G4

## Tray G6

Growth of Crystals From Solutions in Low Gravity (AO139A)

Rockwell International Science Center

Technical University of Denmark

Tray: G6

The objective of this experiment was to develop a novel method for growing single lead sulfide (PbS) crystals from a solute diffusion.

***Figure 537 (Preflight).*** Experiment AO139A consisted of four specially designed reactors that were housed in a thermally controlled aluminum cylinder, heaters, a data recording and control system, and lithium sulfadioxide batteries as the power source. The experiment was thermally isolated from the albedo of the Earth by an aluminum cover plate that was attached to clips, which were installed on the experiment tray sidewalls. The outward facing surface of the cover plate was coated with Chemglaze A276 white paint over Chemglaze 9924 wash primer. The aluminum surface that was facing the tray interior remained uncoated.

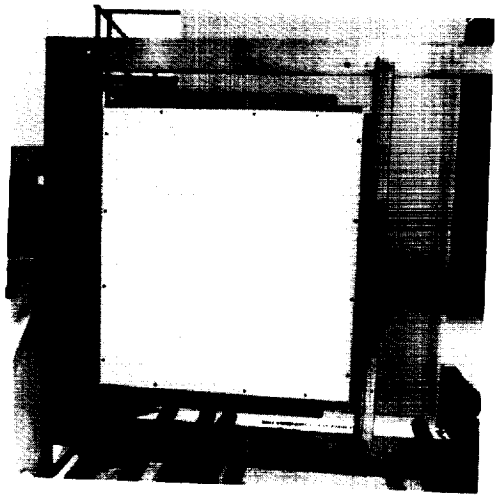

Figure 537
Photo No.: KSC-384C-256.02
Dup. Neg. No.: L89-4391
LISAR NO.: EL-1994-00381
Photo Credit: KSC
Photo Date: 1/18/84
Location: KSC SAEF II
Subject: Preflight Survey of Tray G6

***Figure 538 (In Flight).*** The cover plate appears brown because of the lighting. Later photographs indicated that the cover was a slightly discolored white. The narrow band of discolorations at the right, left, and upper edges of the cover plate appears to be areas of masking tape residue that have turned brown.

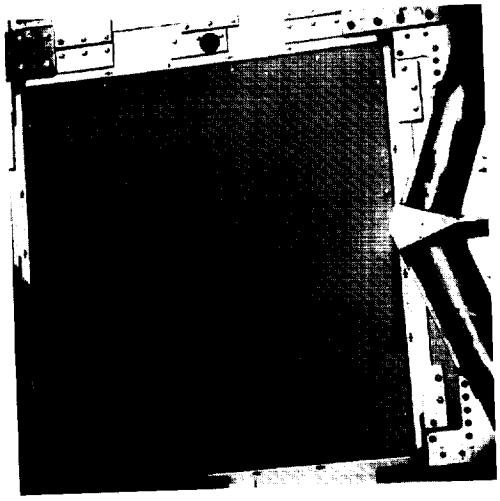

Figure 538
Photo No.: S32-76-066
Dup. Neg. No.: L90-10391
LISAR NO.: EL-1994-00081
Photo Credit: JSC
Photo Date: 1/12/90
Location: In Flight
Subject: In-Flight Survey of Tray G6

***Figure 539 (Postflight).*** Experiment (AO139A) appears to have survived the extended mission with no visible damage. Some discoloration appears near the center of the left flange of the tray. The experiment cover plate, which was originally white, is discolored by a very light brown stain, but it is intact and securely in place.

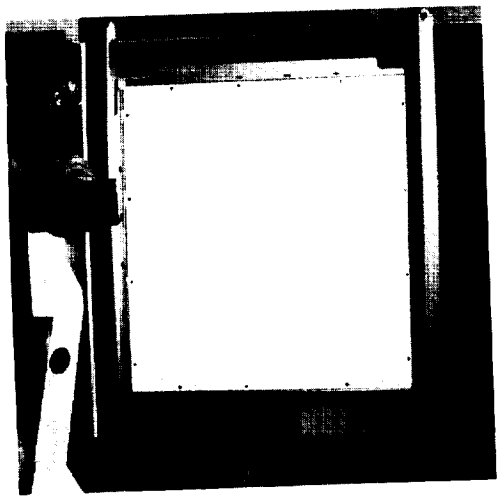

Figure 539
Photo No.: KSC-390C-1704.05
Dup. Neg.: L91-11642
LISAR NO.: EL-1994-00265
Photo Credit: KSC
Photo Date: 3/7/90
Location: KSC SAEF II
Subject: Postflight Survey of Tray G6

***Figure 540 (Postflight).*** This photograph is of the tray after the thermal cover has been removed. The four specially designed reactors are housed in the thermally controlled aluminum cylinder in the center of the tray.

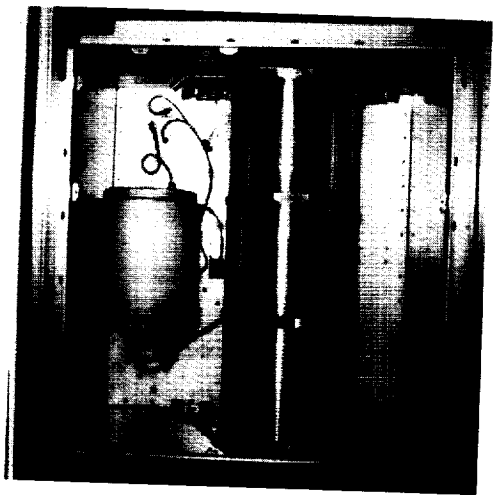

Figure 540
Photo No.: KSC-390C-1740.12
Dup. Neg. No.: L91-11660
LISAR NO.: EL-1994-00711
Photo Credit: KSC
Photo Date: 3/8/90
Location: KSC SAEF II
Subject: Postflight Detail With Thermal Cover Removed of Tray G6

## Tray G8

Space Debris Impact Experiment (S0001)

NASA LaRC

Trays: A5, A6, A12, B1, B2, B6, B8, B11, C4, C7, D2, D6, E1, E4, E7, E11, F1, F3, F5, F7, F10, F11, G4, G8, and H5

See section entitled "Tray A5" for experiment objective. No preflight photograph was available.

***Figure 541 (In Flight).*** The darkness in the left section of the debris panel is attributed to the lighting, although the panel appears to have a light discoloration. The scrapes and scratch marks are from preflight handling and are not mission related.

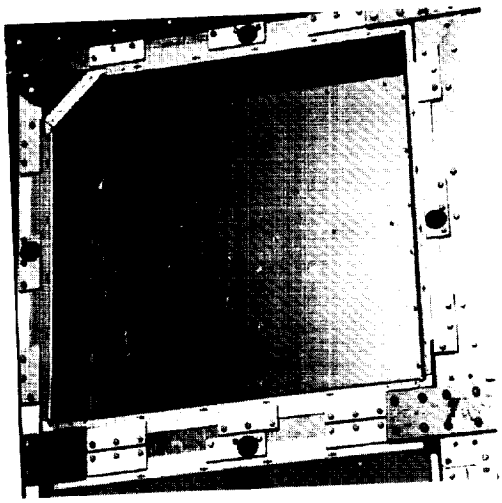

Figure 541
Photo No.: S32-76-077
Dup. Neg. No.: L90-10394
LISAR NO.: EL-1994-00058
Photo Credit: JSC
Photo Date: 1/12/90
Location: In Flight
Subject: In-Flight Survey of Tray G8

***Figure 542 (Postflight).*** Irregular tan discolorations are visible on the lower experiment tray sidewall. The pink tint on the debris panel is a by-product of the chromic anodize coating process and is not attributed to contamination or exposure to the space environment. The light spots on the debris panel are the same abrasions that were observed in the in-flight photograph.

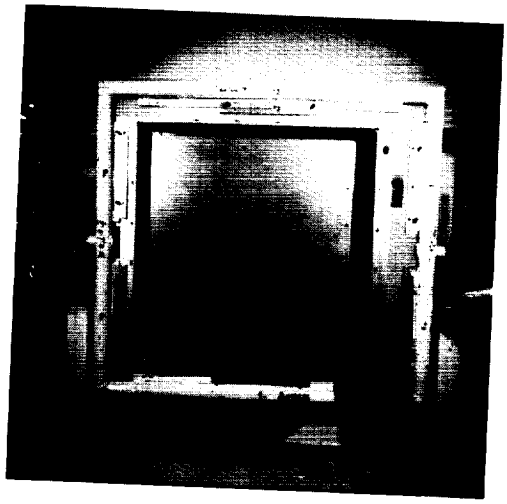

Figure 542
Photo No.: KSC-390C-2308.09
Dup. Neg. No.: L91-11669
LISAR NO.: EL-1994-00313
Photo Credit: KSC
Photo Date: 3/26/90
Location: KSC SAEF II
Subject: Postflight Survey of Tray G8

## Tray G10

Interplanetary Dust Experiment (IDE) (AO201)

Institute for Space Science and Technology

NASA LaRC

North Carolina State University

Trays: B12, C3, C9, D6, G10, and H11

The objective of this experiment was to study interplanetary dust and obtain information about particle mass and velocity.

***Figure 543 (Preflight).*** Experiment AO201 was an active experiment that exposed 80 detectors to the space environment. The experiment is described in the section "Preflight Figure 209." The colors on the detectors are the reflections of technicians and the surrounding clean room work area.

Figure 543
Photo No.: KSC-384C-8.06
Dup. Neg. No.: L84-7001
LISAR NO.: EL-1994-00334
Photo Credit: KSC
Photo Date: 1/10/84
Location: KSC SAEF II
Subject: Preflight Survey of Tray G10

***Figure 544 (In Flight).*** All experiment hardware seems to be in excellent condition and bond joints have maintained their integrity. The blue on the mirrorlike surface of the detectors is caused by reflections of the surroundings.

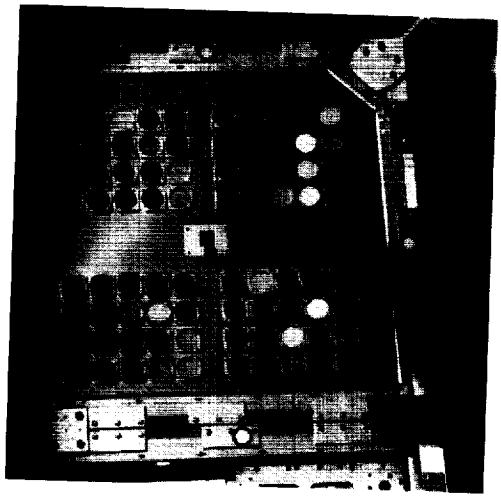

Figure 544
Photo No.: S32-76-050
Dup. Neg. No.: L90-10387
LISAR NO.: EL-1994-00667
Photo Credit: JSC
Photo Date: 1/12/90
Location: In Flight
Subject: In-Flight Survey of Tray G10

***Figure 545 (Postflight).*** Experiment AO201 appears to have no visible degradation. The blue in the metallic surface of the detectors is caused by reflections of the surrounding area.

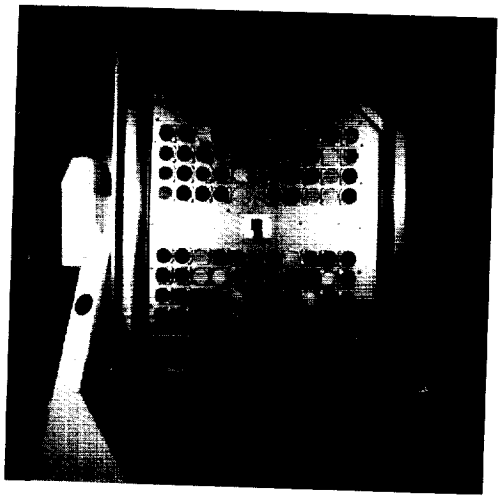

Figure 545
Photo No.: KSC-390C-2068.08
Dup. Neg. No.: L91-11688
LISAR NO.: EL-1994-00298
Photo Credit: KSC
Photo Date: 3/19/90
Location: KSC SAEF II
Subject: Postflight Survey of Tray G10

***Figure 546 (Postflight).*** This photograph is of the upper left one-fourth of the tray. The blue on the mirrorlike surface of the detectors is caused by reflections of the surroundings. Small impact craters are visible on some detectors. Surface scratches are also visible on the baseplate.

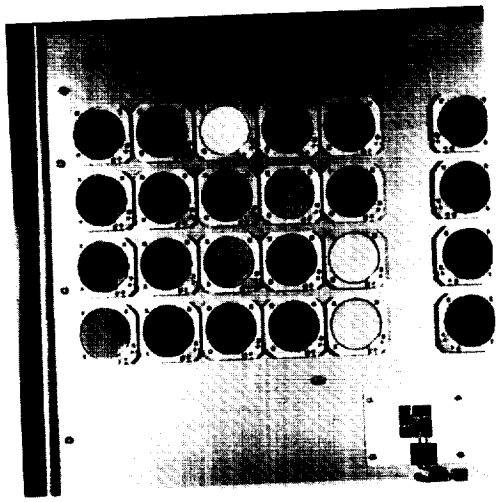

Figure 546
Photo No. KSC-390C-2068.09
Dup. Neg. No.: L91-11689
LISAR NO.: EL-1994-00468
Photo Credit: KSC
Photo Date: 3/19/90
Location: KSC SAEF II
Subject: Postflight Detail of Upper Left of Tray G10

***Figure 547 (Postflight).*** This photograph is of the upper right one-fourth of the tray. Small impact craters are visible on some detectors. The blue on the mirrorlike surface of the detectors is caused by reflections of the surroundings. Surface scratches are visible on the baseplate.

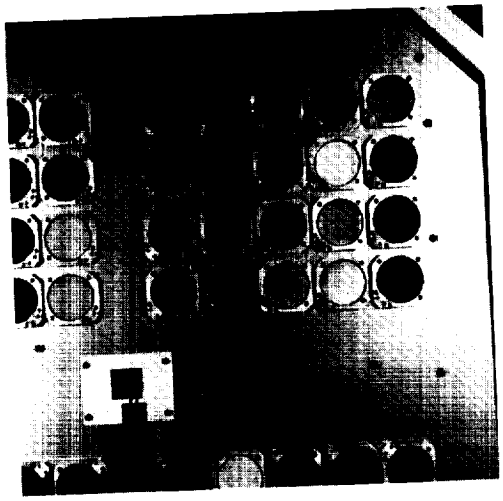

Figure 547
Photo No. KSC-390C-2068.10
Dup. Neg. No.: L91-11690
LISAR NO.: EL-1994-00469
Photo Credit: KSC
Photo Date: 3/19/90
Location: KSC SAEF II
Subject: Postflight Detail of Upper Right of Tray G10

***Figure 548 (Postflight).*** This photograph is of the lower left one-fourth of the tray. The blue on the mirrorlike surface of the detectors is caused by reflections of the surroundings. Small impact craters are visible on some detectors. Surface scratches are also visible on the baseplate. A pie-shaped discoloration is visible on the detector found second from the left and second from the bottom.

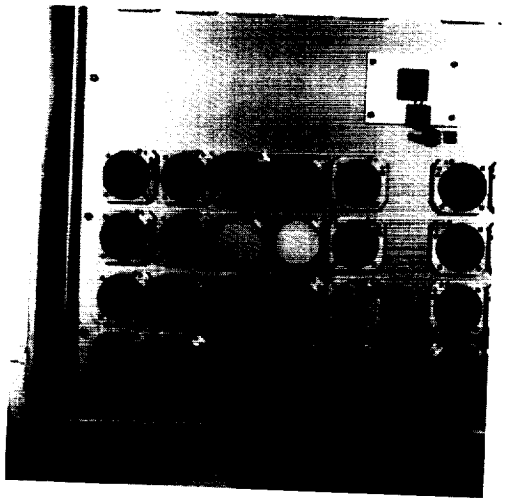

Figure 548
Photo No. KSC-390C-2068.11
Dup. Neg. No.: L91-11691
LISAR NO.: EL-1994-00470
Photo Credit: KSC
Photo Date: 3/19/90
Location: KSC SAEF II
Subject: Postflight Detail of Lower Left of Tray G10

***Figure 549 (Postflight).*** This photograph is of the lower right one-fourth of the tray. The blue on the mirrorlike surface of the detectors is caused by reflections of the surroundings. Small impact craters are visible on some detectors. Surface scratches are visible on the baseplate.

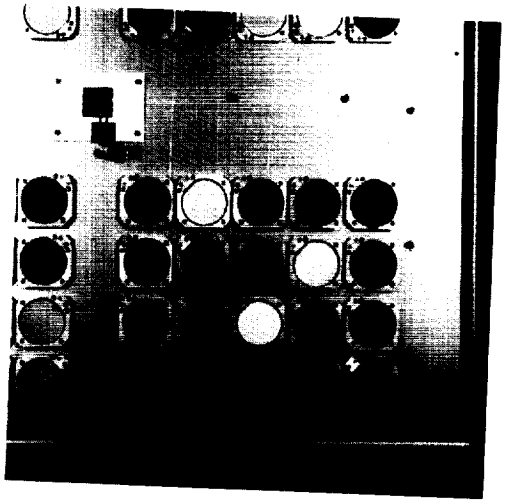

Figure 549
Photo No. KSC-390C-2068.12
Dup. Neg. No.: L91-11692
LISAR NO.: EL-1994-00471
Photo Credit: KSC
Photo Date: 3/19/90
Location: KSC SAEF II
Subject: Postflight Detail of Lower Right of Tray G10

## Tray G12

Exposure to Space Radiation of High-Performance Infrared Multilayer Filters and Materials Technology Experiments (AO056)

University of Reading

British Aerospace Corporation

Trays: B8 and G12

The objectives of these experiments were to expose high-performance infrared multilayer filters and finishes and adhesive systems to the low-Earth-orbit space environment. The filters, finishes, and adhesive systems would then be measured to ascertain their suitability for use in spacecraft and to understand their degradation mechanisms.

Passive Exposure of Earth Radiation Budget Experiment Components (AO147)

The Eppley Laboratory, Inc.

Trays: B8 and G12

The objective of this experiment was to expose channel components of the Earth Radiation Budget Experiment to the space environment and then to submit the components to radiometric calibration. This experiment intended to apply corrections to results from the Earth Radiation Budget Experiment and to use the information in the selection of components for future solar and ERB experiments.

Effects of Solar Radiation on Glasses (AO172)

NASA MSFC

Vanderbilt University

Trays: D2 and G12

The objectives of this experiment were to determine the effects of solar radiation and space environment on glasses.

Trapped Proton Energy Spectrum Determination (M0002-1)

Air Force Geophysics Laboratory

NASA MSFC

Army Materials and Mechanics Research Center

Clarkson College of Technology

Emmanuel College

Eastern Kentucky University

Trays: D3, D9, and G12

The objectives of this experiment were to measure the flux and the energy spectrum of protons with energies of 1 to 10 MeV.

***Figure 550 (Preflight).*** Experiment AO056 was composed of a module containing 20 specimens that were located in the upper right quadrant of the integrated tray. Experiment AO147 was located in the lower left quadrant of the integrated tray. Experiment AO172, which was located in the lower right quadrant of the integrated tray, contained 52 disc-shaped glass samples. Experiment M0002-1, which was located in the upper left quadrant of the integrated tray, consisted of a primary experiment and three smaller related experiments on an aluminum mounting plate. The exterior surfaces of the mounting plate, the experiment housings, and the support structure were coated with IITRE S13G-LO white paint.

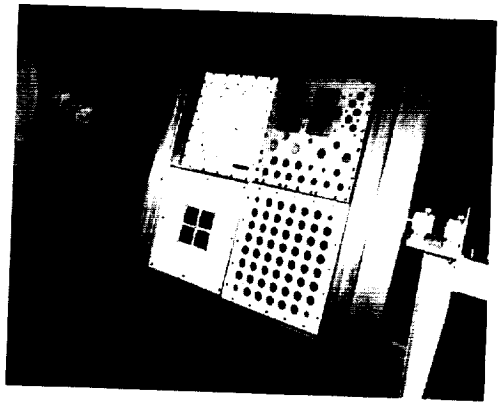

Figure 550
Photo No.: KSC-384C-317.08
Dup. Neg. No.: L84-7165
LISAR NO.: EL-1994-00643
Photo Credit: KSC
Photo Date: 1/23/84
Location: KSC SAEF II
Subject: Preflight Survey of Tray G12

***Figure 551 (In Flight).*** Shadows of the remote manipulator system cover a significant area of the picture. A light tan discoloration is visible on the baseplates and the mounting surfaces of the experiments. All experiment hardware appears intact.

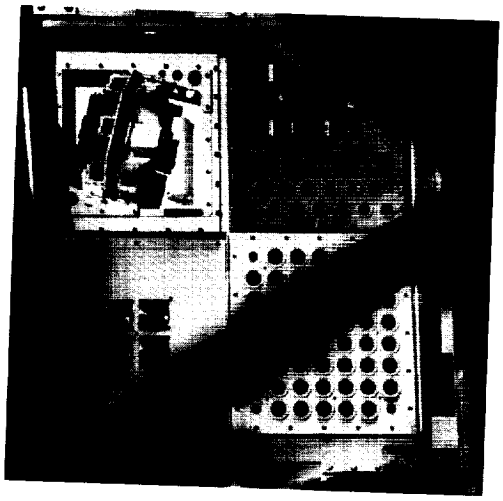

Figure 551
Photo No.: S32-76-054
Dup. Neg. No.: L90-10388
LISAR NO.: EL-1994-00668
Photo Credit: JSC
Photo Date: 1/12/90
Location: In Flight
Subject: In-Flight Survey of Tray G12

***Figure 552 (Postflight).*** The experiment hardware appears intact. There are areas of discoloration on the baseplates and mounting structure of the experiments. The cover plate of experiment AO147 in the lower left, which was originally painted with Chemglaze II A276, now has a light tan discoloration over most of the surface area.

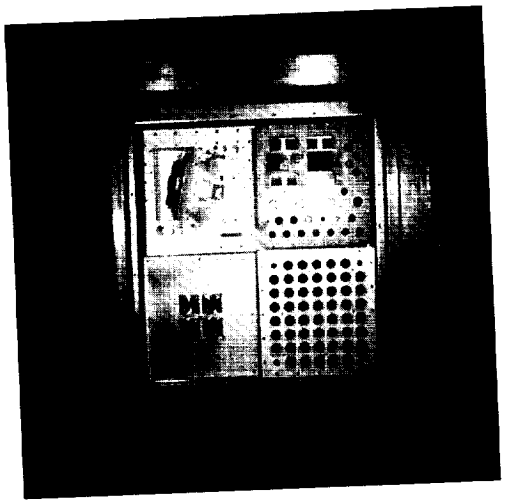

Figure 552
Photo No.: KSC-390C-1997.02
Dup. Neg. No.: L91-11718
LISAR NO.: EL-1994-00296
Photo Credit: KSC
Photo Date: 3/15/90
Location: KSC SAEF II
Subject: Postflight Survey of Tray G12

***Figure 553 (Postflight).*** This photograph is of the upper left one-fourth of the tray. Experiment M0002-1 has a brown discoloration that is concentrated more heavily on areas that are away from the base. The hardware and sensors are intact.

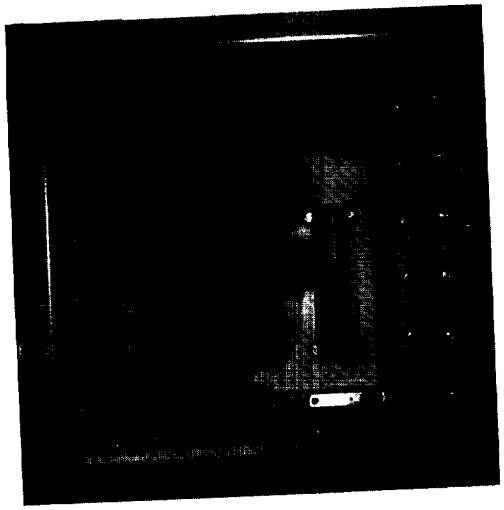

Figure 553
Photo No.: KSC-390C-1997.03
Dup. Neg. No.: L91-11719
LISAR NO.: EL-1994-00442
Photo Credit: KSC
Photo Date: 3/15/90
Location: KSC SAEF II
Subject: Postflight Detail of Upper Left of Tray G12

***Figure 554 (Postflight).*** This photograph is of the upper right one-fourth of the tray. The faceplate of experiment AO056, which is painted with Chemglaze II A276 white paint, is much darker than in the preflight photograph. The discoloration is not uniform.

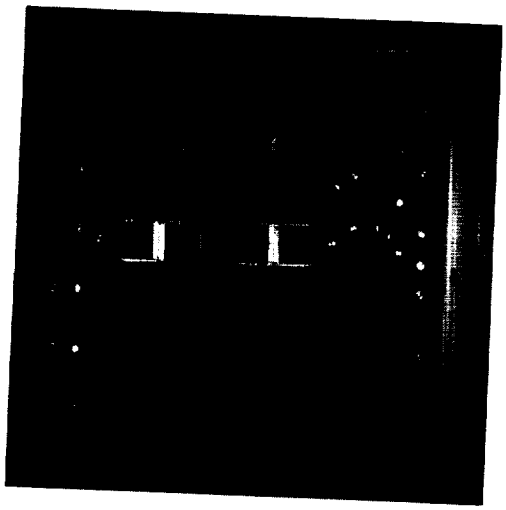

Figure 554
Photo No.: KSC-390C-1997.04
Dup. Neg. No.: L91-11720
LISAR NO.: EL-1994-00443
Photo Credit: KSC
Photo Date: 3/15/90
Location: KSC SAEF II
Subject: Postflight Detail of Upper Right of Tray G12

***Figure 555 (Postflight).*** This photograph is of the lower left one-fourth of the tray. The faceplate of experiment AO147, which was painted with Chemglaze II A276, has areas of brown discoloration that are concentrated more on the left side. Note the discoloration flow pattern below the fasteners. The sensors are intact.

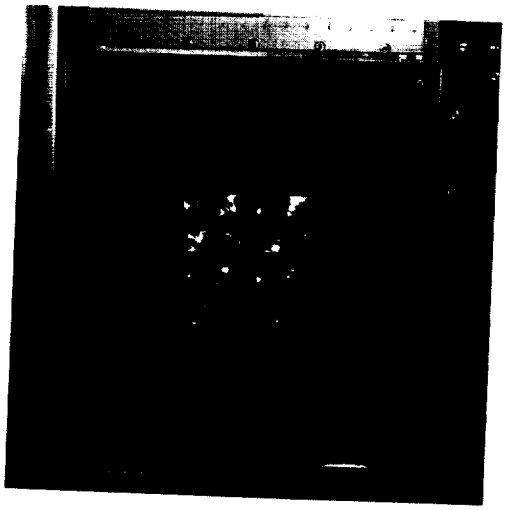

Figure 555
Photo No.: KSC-390C-1997.05
Dup. Neg. No.: L91-11721
LISAR NO.: EL-1994-00444
Photo Credit: KSC
Photo Date: 3/15/90
Location: KSC SAEF II
Subject: Postflight Detail of Lower Left of Tray G12

***Figure 556 (Postflight).*** This photograph is of the lower right one-fourth of the tray. The faceplate that was painted with Chemglaze II A276 white paint is slightly less white than in preflight. There are brown discoloration flow patterns below some of the sample holders. The test samples are intact.

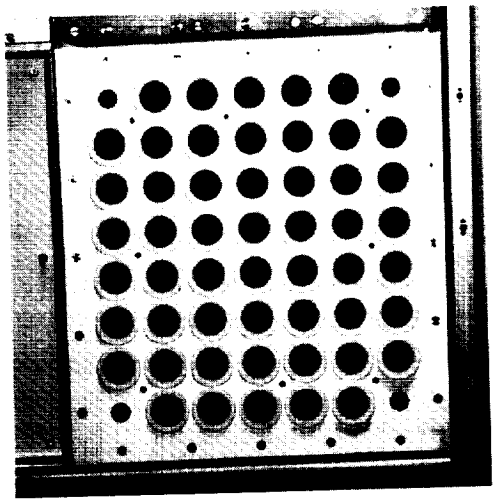

Figure 556
Photo No.: KSC-390C-1997.06
Dup. Neg. No.: L91-11722
LISAR NO.: EL-1994-00445
Photo Credit: KSC
Photo Date: 3/15/90
Location: KSC SAEF II
Subject: Postflight Detail of Lower Right of Tray G12

## Tray H1

Low-Temperature Heat Pipe Experiment Package for LDEF (HEPP) (S1001)

NASA GSFC

NASA ARC

Trays: F12 and H1

The objectives of this experiment were to determine start-up performance for conventional and diode low-temperature heat pipes in zero gravity, to evaluate heat pipe performance for an extended period of time in zero gravity, to determine transport capability of each heat pipe in zero gravity, and to determine diode operation, such as forward conductance, turndown ratio, and transient behavior.

***Figure 557 (Preflight).*** This power tray is for experiment S1001. The electrical cables in the photograph are nonflight cables that connected the power tray with the experiment tray and the ground support test equipment. The power system tray is shown with four red solar array protective covers that were installed on an aluminum baseplate. The power tray contained four solar array panels, one nickel cadmium (NiCd) battery, a power system electronics (PSE) unit, protective thermal blankets, and a 37-lb baseplate (thermal mass). Thirteen strips of thin-film thermal control materials, which are part of an atomic oxygen experiment that consisted of 65 samples located at three different tray locations (H1, F9, and F12), were attached to the experiment tray flanges with Kapton tape.

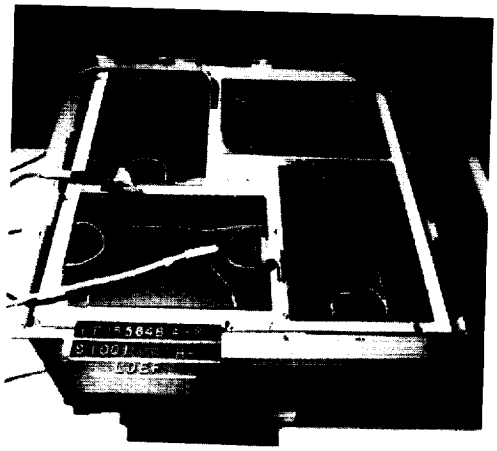

Figure 557
Photo No.: KSC-383C-4419.12
Dup. Neg. No.: L84-7331
LISAR NO.: EL-1994-00318
Photo Credit: KSC
Photo Date: 12/8/83
Location: KSC SAEF II
Subject: Preflight Survey of Tray H1

***Figure 558 (In Flight).*** The white paint dots on the center clamp blocks of the right flange and lower flange of the experiment tray are discolored. The discoloration diminishes as the distance from the vent area of the thermal panels increases. The right and lower tray flanges near the vents also are discolored. Fingerprints are visible on the thermal panels in the vicinity of the panel mounting fasteners. The experiment hardware appears to be intact with no apparent changes other than stains along outer edges of the solar arrays.

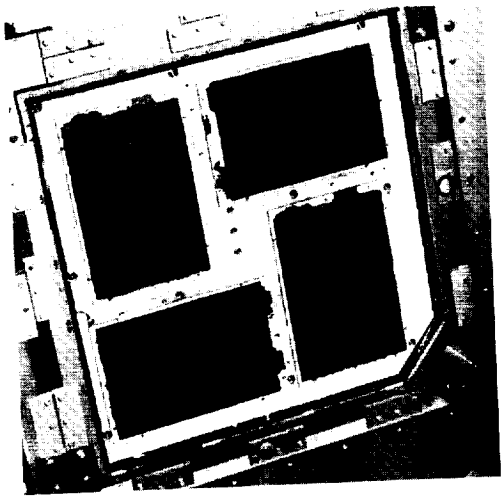

Figure 558
Photo No.: S32-75-036
Dup. Neg. No.: L90-10355
LISAR NO.: EL-1994-00085
Photo Credit: JSC
Photo Date: 1/12/90
Location: In Flight
Subject: In-Flight Survey of Tray H1

***Figure 559 (Postflight).*** This photograph of experiment S1001 was taken from the cargo bay access hatch of the orbiter during postlanding operations at Dryden Flight Research Center. Note the discolorations on the structure of the LDEF, tray flanges, and tray clamp white dots. Note also the variation of discoloration with proximity to the thermal panel vents. Fingerprints are visible on the thermal panels in the vicinity of the panel mounting fasteners. The experiment hardware is intact with no apparent changes other than stains along outer edges of the solar arrays. The atomic oxygen samples in the upper left corner of the tray appear to be degraded. The Kapton tape is loose on the sample in the lower right corner of the tray and on the center sample on the upper tray flange. In other areas, the tape appears to be firmly adhered to the tray flanges.

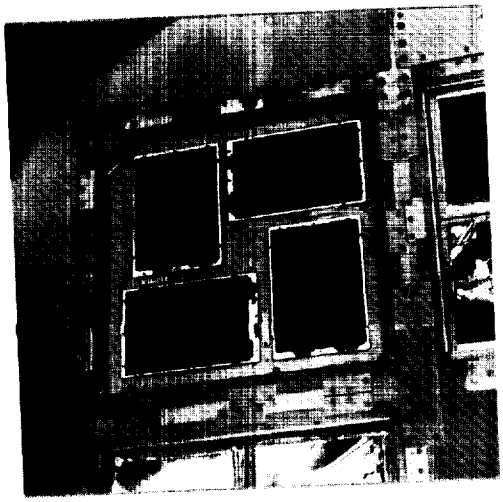

Figure 559
Photo No.: S32-S-282
Dup. Neg. No.: L92-21189
LISAR NO.: EL-1994-00071
Photo Credit: JSC
Photo Date: 1/22/90
Location: Shuttle Cargo Bay at Dryden
Subject: Postflight Survey of Tray H1

***Figure 560 (Postflight).*** The experiment hardware is intact with no apparent changes other than stains along outer edges of the solar arrays. The light brown stains observed along the upper edges of the solar array mounting plates and around the outer edge of the baseplate in the in-flight photograph are not apparent in this postflight photograph.

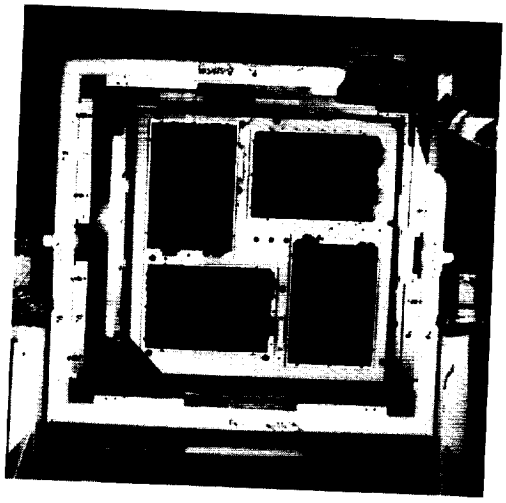

Figure 560
Photo No.: KSC-390C-2367.04
Dup. Neg. No.: L91-11748
LISAR NO.: EL-1994-00315
Photo Credit: KSC
Photo Date: 3/28/90
Location: KSC SAEF II
Subject: Postflight Survey of Tray H1

***Figure 561 (Postflight).*** This photograph is of the upper left one-fourth of the tray. The solar cells appear intact. A few small impact craters on the array are visible. The atomic oxygen experiment samples that were attached to the tray flanges with Kapton tape are in place.

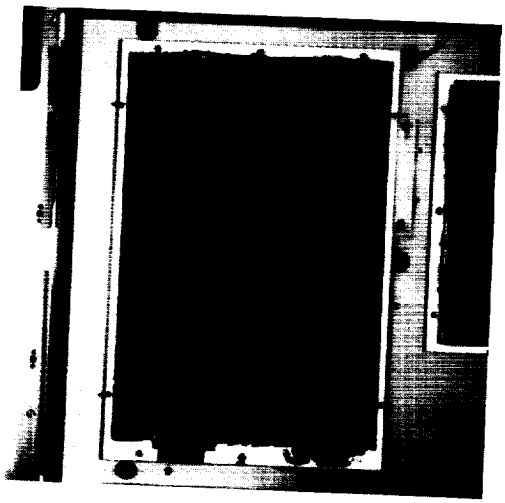

Figure 561
Photo No.: KSC-390C-2367.05
Dup. Neg. No.: L91-11749
LISAR NO.: EL-1994-00622
Photo Credit: KSC
Photo Date: 3/28/90
Location: KSC SAEF II
Subject: Postflight Detail of Upper Left of Tray H1

***Figure 562 (Postflight).*** This photograph is of the upper right one-fourth of the tray. The solar cells appear intact. A few small impact craters on the array are visible. The Kapton tape that is holding atomic oxygen experiment samples to the tray flange is loose.

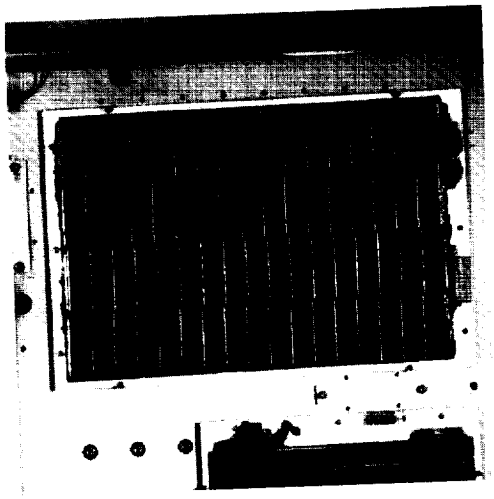

Figure 562
Photo No.: KSC-390C-2367.06
Dup. Neg. No.: L91-11750
LISAR NO.: EL-1994-00623
Photo Credit: KSC
Photo Date: 3/28/90
Location: KSC SAEF II
Subject: Postflight Detail of Upper Right of Tray H1

***Figure 563 (Postflight).*** This photograph is of the lower left one-fourth of the tray. The solar cells appear intact. A few small impact craters on the array are visible. The atomic oxygen experiment samples on the left and in the center that were attached to the tray flanges with Kapton tape are damaged.

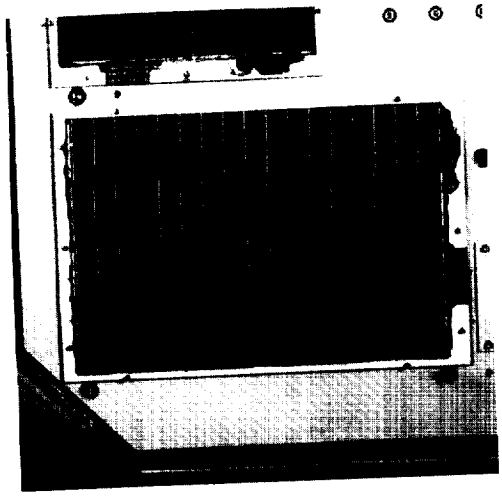

Figure 563
Photo No.: KSC-390C-2367.07
Dup. Neg. No.: L91-11751
LISAR NO.: EL-1994-00618
Photo Credit: KSC
Photo Date: 3/28/90
Location: KSC SAEF II
Subject: Postflight Detail of Lower Left of Tray H1

***Figure 564 (Postflight).*** This photograph is of the lower right one-fourth of the tray. The solar cells appear intact. A few small impact craters on the array are visible. The atomic oxygen experiment samples attached to the tray flanges with Kapton tape are in place.

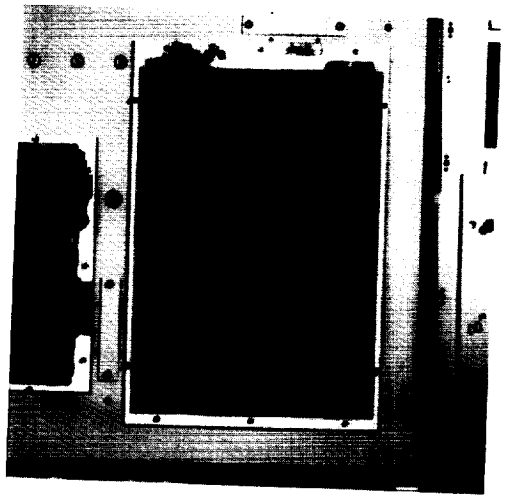

Figure 564
Photo No.: KSC-390C-2367.08
Dup. Neg. No.: L91-11752
LISAR NO.: EL-1994-00624
Photo Credit: KSC
Photo Date: 3/28/90
Location: KSC SAEF II
Subject: Postflight Detail of Lower Right of Tray H1

## Tray H3

Heavy Ions in Space (M0001)

Naval Research Laboratory

Trays: H3 and H12

The objective of this experiment was to provide a deep survey of intensely ionizing particles in low Earth orbit.

***Figure 565 (Preflight).*** The prelaunch photograph shows four experiment modules that were mounted in the experiment tray. An experiment module consisted of a multilayer thermal insulation blanket, a top stack of Lexan sheets for detecting low-energy ions, a honeycomb pressure cover, and the main stack of CR-39 sheets, which was used to detect cosmic rays. The four modules were identical in materials and construction. The top layer of the thermal blanket is a 5-mil Kapton film with an aluminum coating vapor deposited on the underside and an overcoat of Chemglaze II A-276 white paint on the exterior. The center section of the thermal blanket is constructed of approximately 22 layers of 1/4-mil perforated Mylar film with an aluminum coating vapor deposited on each side. The bottom layer of the thermal blanket is a 5-mil Kapton film with an aluminum coating vapor deposited on the side facing the Lexan detector stack sheet. A Dacron mesh (bridal veil) separator is placed between each aluminized Mylar layer of the core material. The frame around each of the four modules, which was a Z-shaped aluminum structure, was covered with a silvered Teflon film that was secured with acrylic transfer tape. The transfer tape on a silvered Teflon film was also used to attach the edges of the multilayer thermal blankets to the frame of the module.

Figure 565
Photo No. KSC-384C-318.01
Dup. Neg. No.: L89-4397
LISAR NO.: EL-1994-00709
Photo Credit: KSC
Photo Date: 1/23/84
Location: KSC SAEF II
Subject: Preflight Survey of Tray H3

***Figure 566 (In Flight).*** A light tan stain is visible on the end structure along the left edge of the tray flange. Lighter stains are also visible on the tray flange between the top and the center tray clamp blocks on the left side. The multilayer thermal insulation blanket has extensive damage. The tape joints have failed along two sides of each experiment module and have allowed the thermal blanket to curl back over itself. The gold-colored surfaces that have then been exposed are the top sheet of the Lexan detector stacks that are held securely in place by the Z shaped aluminum structure.

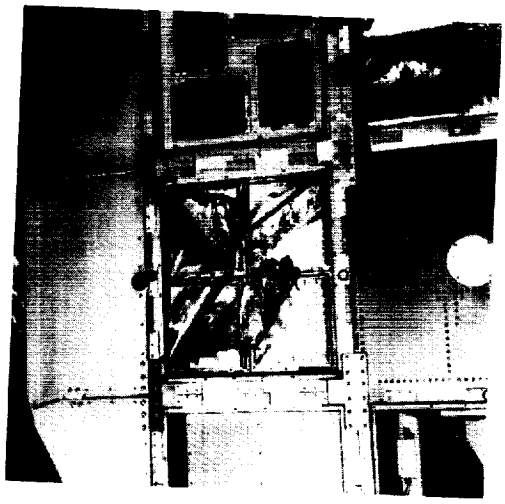

Figure 566
Photo No.: S32-75-043
Dup. Neg. No.: L90-10356
LISAR NO.: EL-1994-00670
Photo Credit: JSC
Photo Date: 1/12/90
Location: In Flight
Subject: In-Flight Survey of Tray H3

***Figure 567 (Postflight).*** This photograph, which was taken from the cargo bay access hatch of the orbiter during postlanding operations at the Dryden Flight Research Center, shows extensive damage to the multilayer thermal insulation blanket. The tape joints appear to have failed along two sides of each experiment module and allowed the multilayer thermal insulation blanket to curl back over itself. The curls are now tighter than they were in flight. Note the discolorations on the structure of the LDEF, tray flanges, and tray clamp white dots and the variation of discoloration with proximity to the thermal panel vents. The paint on the top layer of the thermal blankets, which was originally white, now appears brown or light tan. The fragments of aluminum in the lower two quadrants appear to be from the delamination of the vapor-deposited aluminum from the thermal insulation blanket.

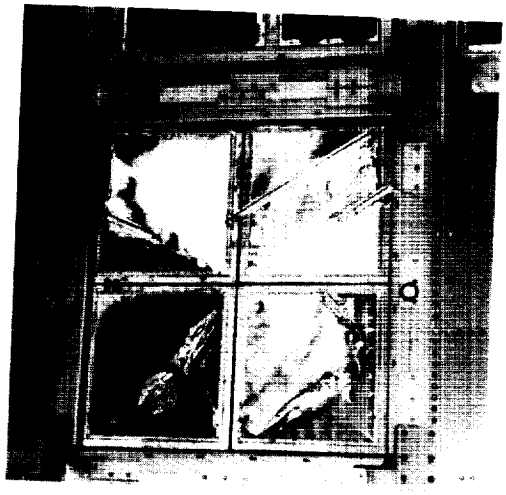

Figure 567
Photo No.: S32-S-278
Dup. Neg. No.: L92-21185
LISAR NO.: EL-1994-00070
Photo Credit: JSC
Photo Date: 1/22/90
Location: Shuttle Cargo Bay at Dryden
Subject: Postflight Survey of Tray H3

***Figure 568 (Postflight).*** This photograph shows the four experiment modules with the thermal blankets severely degraded. The paint on the top layer of the thermal blanket, previously white, is now a glossy tan or soft brown. The tape that was used to attach the thermal blanket to the module frames failed during flight. The tape failed in tension because of thermal shrinkage of the blankets, thus leaving tape on both the frame and the top layer of the thermal blanket. The material exposed underneath the thermal blanket is the top sheet of the detector stack. A Dacron mesh (bridal veil) separator is clearly visible in the upper right module. The coating of vapor-deposited aluminum has delaminated from the Mylar film and the Mylar film has eroded. The delaminated aluminum extends from the blanket in the lower right module. The loss of the Dacron mesh and some of the aluminum delamination is thought to have occurred prior to retrieval; however, a significant portion of the aluminum delamination from the Mylar is thought to have occurred postlanding because of the velocity and direction of air from the cargo bay purge system.

Figure 568
Photo No.: L90-01797
Dup. Neg. No.: None
LISAR NO.: EL-1994-00316
Photo Credit: LaRC
Photo Date: 2/6/90
Location: KSC SAEF II
Subject: Postflight Survey of Tray H3

***Figure 569 (Postflight).*** This photograph of the lower right module shows the discolorations and the extensive damage to the thermal blanket.

Figure 569
Photo No.: KSC-390C-828.01
Dup. Neg. No.: L91-15544
LISAR NO.: EL-1994-00068
Photo Credit: KSC
Photo Date: 2/6/90
Location: KSC SAEF II
Subject: Postflight Detail of Lower Right Module of Tray H3

***Figure 570 (Postflight).*** This photograph of the lower left module shows the discolorations and the extensive damage to the thermal blanket.

Figure 570
Photo No.: KSC-390C-828.02
Dup. Neg. No.: L91-15545
LISAR NO.: EL-1994-00069
Photo Credit: KSC
Photo Date: 2/6/90
Location: KSC SAEF II
Subject: Postflight Detail of Lower Left Module of Tray H3

***Figure 571 (Postflight).*** This photograph of the upper left module shows the discolorations and the extensive damage to the thermal blanket.

Figure 571
Photo No.: KSC-390C-828.03
Dup. Neg. No.: L91-15546
LISAR NO.: EL-1994-00099
Photo Credit: KSC
Photo Date: 2/6/90
Location: KSC SAEF II
Subject: Postflight Detail of Upper Left Module of Tray H3

***Figure 572 (Postflight).*** This photograph of the upper right module shows the discolorations and the extensive damage to the thermal blanket.

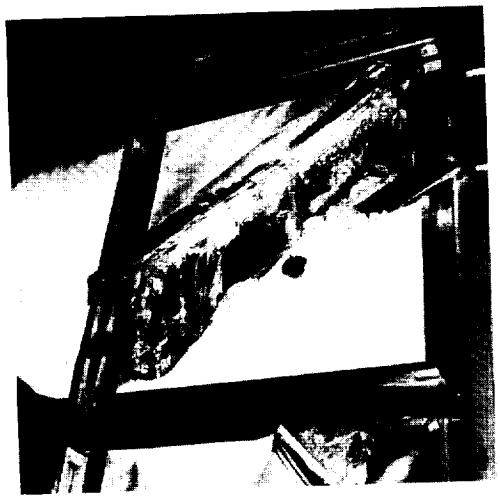

Figure 572
Photo No.: KSC-390C-828.04
Dup. Neg. No.: L91-15547
LISAR NO.: EL-1994-00176
Photo Credit: KSC
Photo Date: 2/6/90
Location: KSC SAEF II
Subject: Postflight Detail of Upper Right Module of Tray H3

***Figure 573 (Postflight).*** This photograph of the upper left module shows the discolorations and the extensive damage to the thermal blanket. A white reference card is also shown in the photograph.

Figure 573
Photo No.: KSC-390C-829.04
Dup. Neg. No.: L91-15559
LISAR NO.: EL-1994-00285
Photo Credit: KSC
Photo Date: 2/6/90
Location: KSC SAEF II
Subject: Postflight Detail of Upper Left Module of Tray H3

## Tray H5

Space Debris Impact Experiment (S0001)

NASA LaRC

Trays: A5, A6, A12, B1, B2, B6, B8, B11, C4, C7, D2, D6, E1, E4, E7, E11, F1, F3, F5, F7, F10, F11, G4, G8, and H5

See section entitled "Tray A5" for experiment objective. No preflight photograph was available.

***Figure 574 (In Flight).*** The paint dots on the experiment tray clamp blocks, which were originally white, show a tan stain that gets darker near the venting area of the end thermal panels. The stain also covers the top and left flanges of the experiment tray. To a lesser degree, the lower and right tray flanges are also covered with the stain. The vertical lines and the pinkish color of the debris panel are chromic anodize coating by-products and are not attributed to contamination or exposure to the space environment.

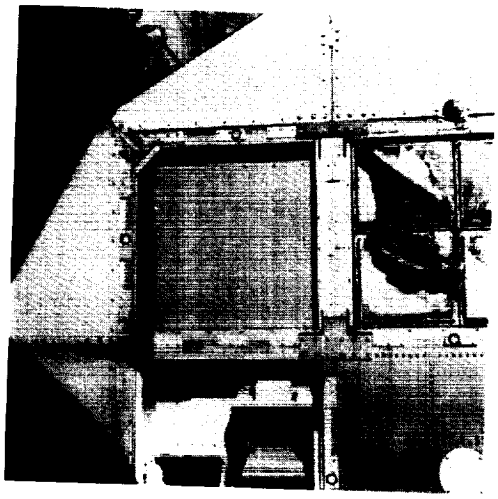

Figure 574
Photo No.: S32-75-064
Dup. Neg. No.: L90-10370
LISAR NO.: EL-1994-00675
Photo Credit: JSC
Photo Date: 1/12/90
Location: In Flight
Subject: In-Flight Survey of Tray H5

***Figure 575 (Postflight).*** This photograph was taken from the cargo bay access hatch of the orbiter during postlanding operations at the Dryden Flight Research Center. Note the discolorations on the structure of the LDEF, tray flanges, and tray clamp white dots and the variation with proximity to the thermal panel vents. The discolorations on the tray sidewalls appear to be fingerprints enhanced by the brown stain. Light discolorations are located near the lower side of the debris panel. The horizontal lines and the pinkish tint of the debris panel are chromic anodize coating by-products and are not attributed to contamination or exposure to the space environment. Darker discolorations on the debris panel, similar to water marks, are apparent in the photograph.

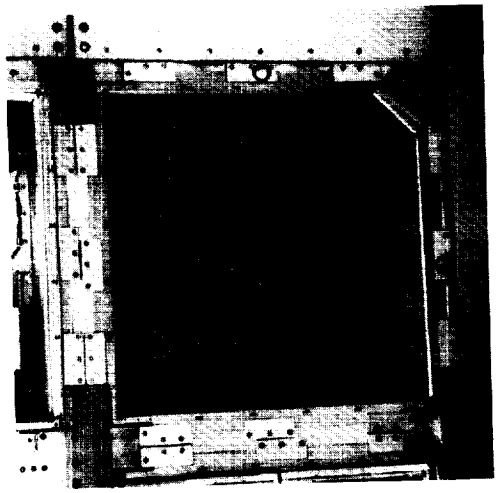

Figure 575
Photo No.: S32-S-293
Dup. Neg. No.: L92-21200
LISAR NO.: EL-1994-00077
Photo Credit: JSC
Photo Date: 1/22/90
Location: Shuttle Cargo Bay at Dryden
Subject: Postflight Survey of Tray H5

***Figure 576 (Postflight).*** A brown discoloration is visible on the lower tray flange and a lighter discoloration is visible on the upper tray flange that is not covered by the experiment tray clamp blocks. Irregular tan discolorations are also visible on the experiment tray lower sidewall with a darker stain in the left tray corners.

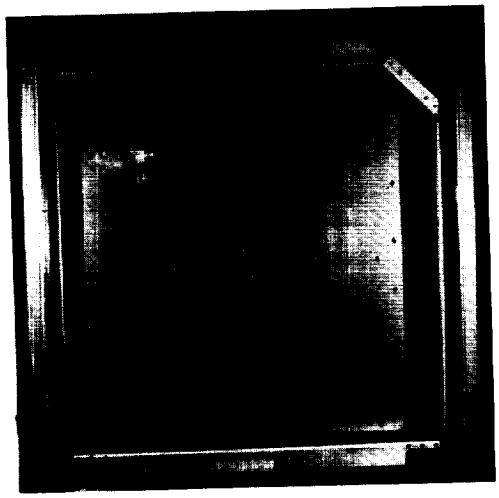

Figure 576
Photo No.: KSC-390C-1701.02
Dup. Neg. No.: L91-11803
LISAR NO.: EL-1994-00264
Photo Credit: KSC
Photo Date: 3/7/90
Location: KSC SAEF II
Subject: Postflight Survey of Tray H5

## Tray H6

Interstellar Gas Experiment (AO038)

JSC

University of Bern

Trays: E12, F6, H6, and H9

Experiment AO038 was designed to collect and isotopically analyze the noble gases in the particle wind that is formed as the local interstellar medium moves through the inner solar system.

***Figure 577 (Preflight).*** The prelaunch photograph experiment AO038 shows two canisters housings that are mounted in a 12-in-deep tray. The experiment utilized canisters containing high-purity beryllium copper collecting foils. The aluminum housing covers, which were removed prior to flight, protected experiment components from damage and large particle contamination during ground handling. The tray is painted white to provide the necessary thermal control.

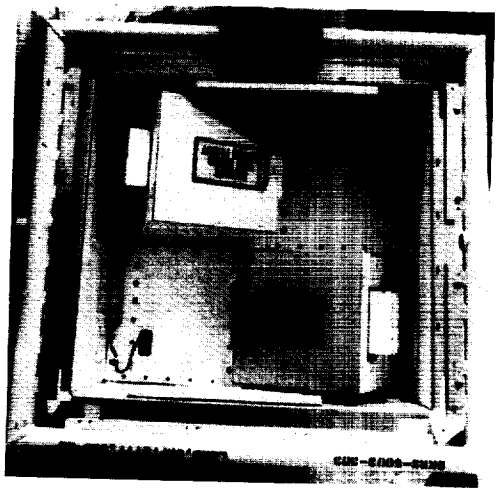

Figure 577
Photo No.: KSC-384C-538.08
Dup. Neg. No.: L89-4420
LISAR NO.: EL-1994-00043
Photo Credit: KSC
Photo Date: 1/30/84
Location: KSC SAEF II
Subject: Preflight Survey of Tray H6

***Figure 578 (In Flight).*** A shadow of the shuttle obscures part of the tray. A very light contamination stain is present on the experiment tray flanges and on most of the visible structure. An exception is a much darker stain on the structure adjacent to thermal panels that provided venting for the interior of the LDEF. The white thermal control paint now varies from off-white to a dark brown. Localized dark brown areas in the tray are visible. A beryllium copper collector foil is clearly visible in the lower left canister housing as are the baffles. Light from the fine wire mesh grid is reflected near the top of the canister housing. Because of an experiment system malfunction, the canister collector foils that are visible were exposed for the total mission.

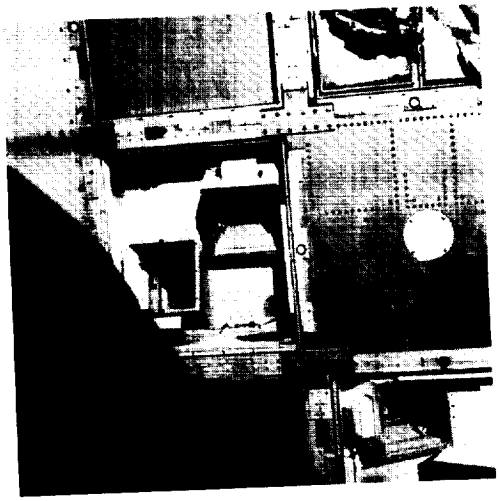

Figure 578
Photo No.: S32-75-063
Dup. Neg. No.: L90-10369
LISAR NO.: EL-1994-00674
Photo Credit: JSC
Photo Date: 1/12/90
Location: In Flight
Subject: In-Flight Survey of Tray H6

***Figure 579 (Postflight).*** This photograph was taken from the cargo bay access hatch of the orbiter during postlanding operations at the Dryden Flight Research Center. Note the discolorations on the structure of the LDEF, tray flanges, and tray clamp white dots and the variation of discoloration with proximity to the thermal panel vents. The darker appearance of the tray interior is probably due to lighting. A beryllium copper collector foil is clearly visible within the canister housings as are the baffles. Reflected light from the fine wire mesh grid is visible near the top of the canister housing.

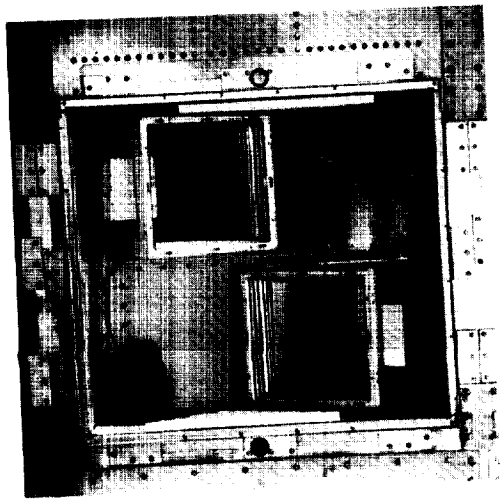

Figure 579
Photo No.: S32(S)-290
Dup. Neg. No.: L92-21197
LISAR NO.: EL-1994-00076
Photo Credit: JSC
Photo Date: 1/22/90
Location: Shuttle Cargo Bay at Dryden
Subject: Postflight Survey of Tray H6

***Figure 580 (Postflight).*** The brown stains are still very prominent and appear to be the same as in the in-flight photograph. The covers have been installed on the canister housings to protect the space-exposed hardware. The contamination stain shows an outline of tray clamp-block locations on the experiment tray flanges.

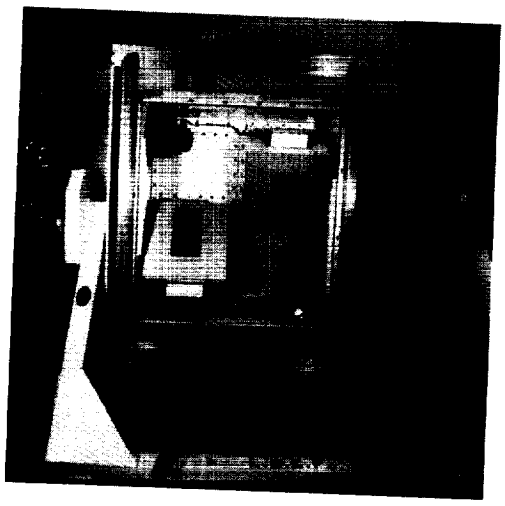

Figure 580
Photo No.: KSC-390C-1641.03
Dup. Neg. No.: L91-11828
LISAR NO.: EL-1994-00215
Photo Credit: KSC
Photo Date: 3/6/90
Location: KSC SAEF II
Subject: Postflight Survey of Tray H6

***Figure 581 (Postflight).*** This photograph is of the upper left one-fourth of the tray. Note the extreme dark brown discoloration around the grid voltage plug in the corner of the tray.

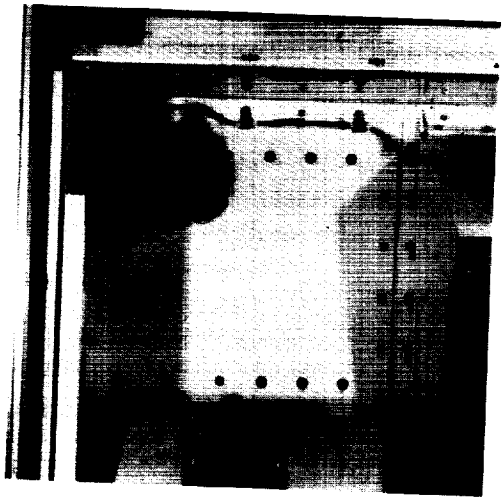

Figure 581
Photo No.: KSC-390C-1641.04
Dup. Neg. No.: L91-11829
LISAR NO.: EL-1994-00051
Photo Credit: KSC
Photo Date: 3/6/90
Location: KSC SAEF II
Subject: Postflight Detail of Upper Left of Tray H6

***Figure 582 (Postflight).*** This photograph is of the upper right one-fourth of the tray. Some dark contamination is visible below the canister. Some shadows are caused by photographic lighting. The cover has been installed on the canister housing to protect the space-exposed hardware.

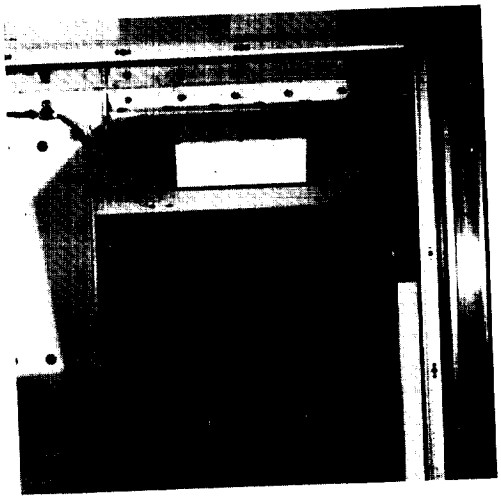

Figure 582
Photo No.: KSC-390C-1641.05
Dup. Neg. No.: L91-11830
LISAR NO.: EL-1994-00052
Photo Credit: KSC
Photo Date: 3/6/90
Location: KSC SAEF II
Subject: Postflight Detail of Upper Right of Tray H6

***Figure 583 (Postflight).*** This photograph is of the lower right one-fourth of the tray. Note the extreme brown discoloration around the grid voltage leads and plug. The cover has been installed on the canister housing to protect the space-exposed hardware.

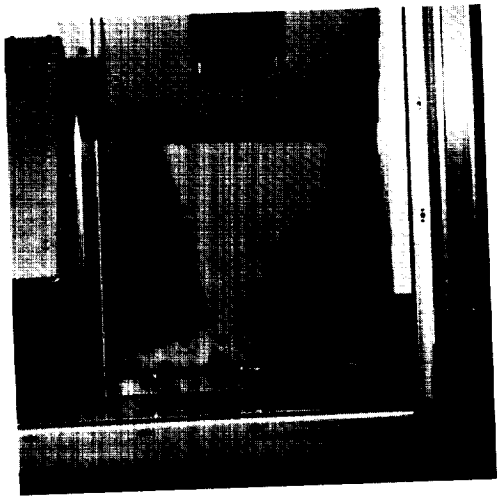

Figure 583
Photo No.: KSC-390C-1641.06
Dup. Neg. No.: L91-11831
LISAR NO.: EL-1994-00053
Photo Credit: KSC
Photo Date: 3/6/90
Location: KSC SAEF II
Subject: Postflight Detail of Lower Right of Tray H6

***Figure 584 (Postflight).*** This photograph is of the lower left one-fourth of the tray. Note the extreme brown discoloration on tray and canister sides. The cover has been installed on the canister housing to protect the space-exposed hardware.

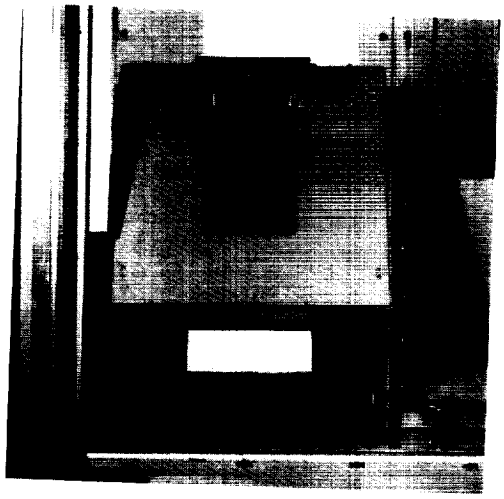

Figure 584
Photo No.: KSC-390C-1641.07
Dup. Neg. No.: L91-11832
LISAR NO.: EL-1994-00216
Photo Credit: KSC
Photo Date: 3/6/90
Location: KSC SAEF II
Subject: Postflight Detail of Lower Left of Tray H6

***Figure 585 (Postflight).*** This close-up photograph is of the lower right corner of the tray. Note the localized extreme brown discoloration around the electrical cable wraps. There is a reflection of the cable in the tray sidewall.

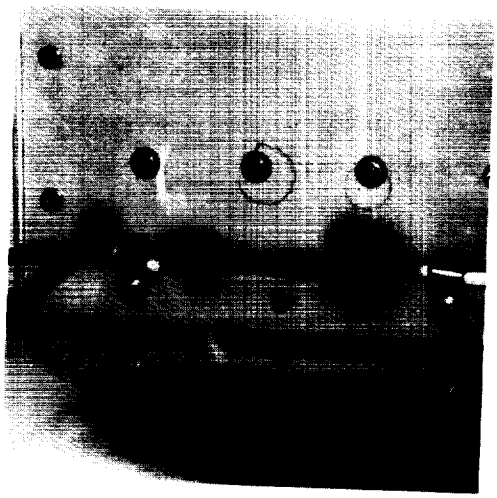

Figure 585
Photo No.: KSC-390C-1642.05
Dup. Neg. No.: L91-11839
LISAR NO.: EL-1994-00261
Photo Credit: KSC
Photo Date: 3/6/90
Location: KSC SAEF II
Subject: Postflight Detail of Lower Right Corner of Tray H6

***Figure 586 (Postflight).*** This close-up photograph is of the lower right corner of the tray. Note the brown discoloration around the grid voltage plug and around the cable wraps.

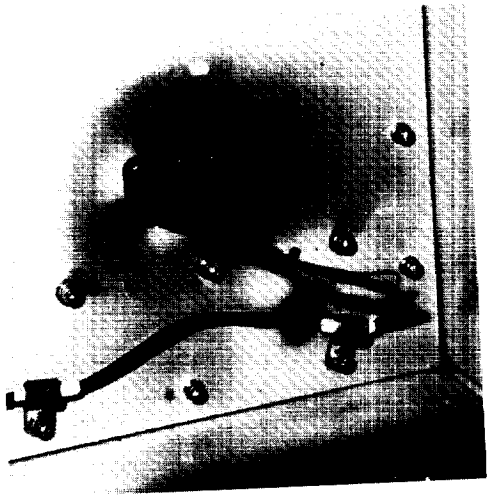

Figure 586
Photo No.: KSC-390C-1642.07
Dup. Neg. No.: L91-11841
LISAR NO.: EL-1994-00276
Photo Credit: KSC
Photo Date: 3/6/90
Location: KSC SAEF II
Subject: Postflight Detail of Lower Right Corner of Tray H6

***Figure 587 (Postflight).*** This close-up photograph is of the upper left corner of the tray. Note the extreme brown discoloration patterns. There is a distinct pattern of the grid voltage cable on the tray side wall.

Figure 587
Photo No.: KSC-390C-1642.08
Dup. Neg. No.: L91-11842
LISAR NO.: EL-1994-00294
Photo Credit: KSC
Photo Date: 3/6/90
Location: KSC SAEF II
Subject: Postflight Detail of Upper Left Corner of Tray H6

***Figure 588 (Postflight).*** This close-up photograph is of the lower canister. There is a discoloration or shielding pattern around the grid voltage plug.

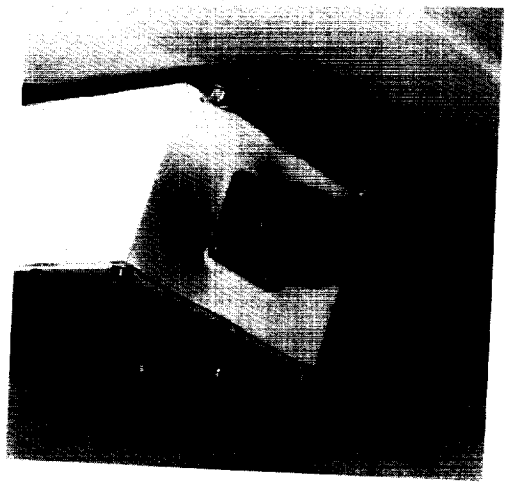

Figure 588
Photo No.: KSC-390C-1642.10
Dup. Neg. No.: L91-11844
LISAR NO.: EL-1994-00310
Photo Credit: KSC
Photo Date: 3/6/90
Location: KSC SAEF II
Subject: Postflight Detail of Lower Canister of Tray H6

***Figure 589 (Postflight).*** This close-up photograph is of the lower left corner of the tray. Note the brown discoloration on the left wall of the tray.

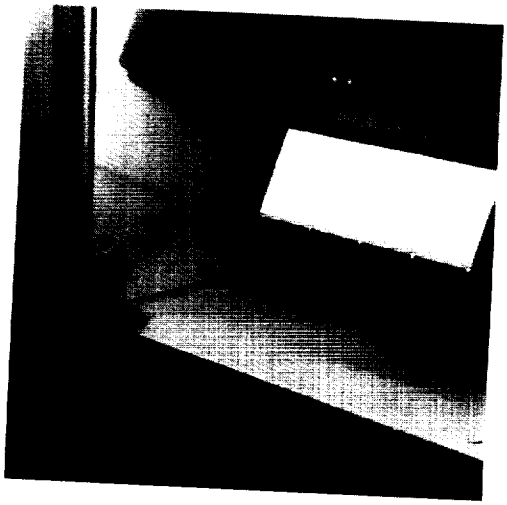

Figure 589
Photo No.: KSC-390C-1643.01
Dup. Neg. No.: L91-11846
LISAR NO.: EL-1994-00353
Photo Credit: KSC
Photo Date: 3/6/90
Location: KSC SAEF II
Subject: Postflight Detail of Lower Left Corner of Tray H6

***Figure 590 (Postflight).*** This close-up photograph is of the upper left corner of the tray. Note the extreme brown discoloration. There is a photographic light reflection just below the grid voltage plug. There is also a reflection of the electrical cable in the tray sidewall.

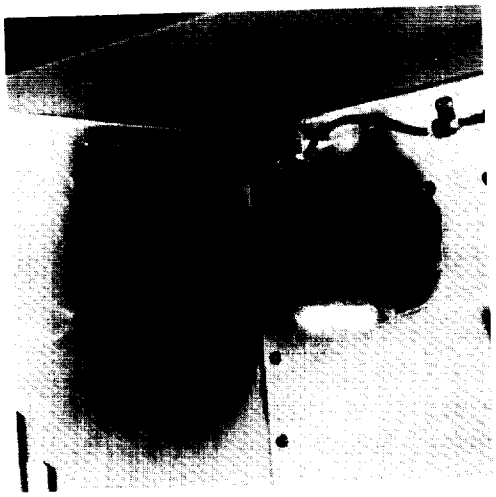

Figure 590
Photo No.: KSC-390C-1643.02
Dup. Neg. No.: L91-11847
LISAR NO.: EL-1994-00366
Photo Credit: KSC
Photo Date: 3/6/90
Location: KSC SAEF II
Subject: Postflight Detail of Upper Left Corner of Tray H6

## Tray H7

Effect of Space Environment on Space-Based Radar Phased-Array Antenna (AO133)

Grumman Aerospace Corporation

Tray: H7

The objective of this experiment was to evaluate the effect of the space environment on the Kapton polyimide film that was considered for the Grumman SBR Phased-Array Antenna.

***Figure 591 (Preflight).*** Experiment AO133 consisted of both passive and active parts. The passive part, which is shown in the left half of the experiment tray, investigated the dimensional stability of Kapton polyimide film when exposed to induced stresses in the space environment. Continuous and spliced specimens of both plain Kapton polyimide film (127-μm thick) and glass-reinforced Kapton polyimide film (196-μm thick) were exposed. The specimens were stretched over an aluminum roller assembly with a spring-loaded mechanism to provide preselected stresses. An aluminum support structure housed two identical sets of specimens: one exposed to the total environment and one protected. The active part of the experiment, which was located in the right half of the tray, investigated the interaction between high voltage and low-Earth-orbit plasma. A 14-in-wide by 28-in-long section of the Grumman SBR Phased-Array Antenna consisted of two Kapton film antenna planes and a perforated aluminum ground plane that was mounted on an aluminum support structure. Copper dipole elements deposited on the Kapton film antenna plane provided the high-voltage electrodes.

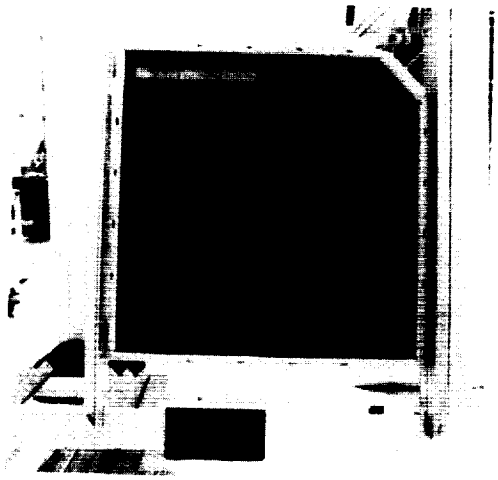

Figure 591
Photo No.: KSC-384C-255.09
LISAR NO.: EL-1994-00373
Dup. Neg. No.: L89-4390
Photo Credit: KSC
Photo Date: 1/18/84
Location: KSC SAEF II
Subject: Preflight Survey of Tray H7

***Figure 592 (In Flight).*** A shadow cast by the orbiter covers most of the left half of the tray, which contains the active part of the experiment. The experiment appears to be without physical damage. Even in the shadow, a light tan discoloration is visible on the left and lower flanges of the experiment tray. A darker stain has discolored the originally white paint dots on the experiment tray clamp blocks. Dark brown stains on the structure of the LDEF are visible in areas adjacent to the edge of thermal end panels that were designed to facilitate venting of the interior.

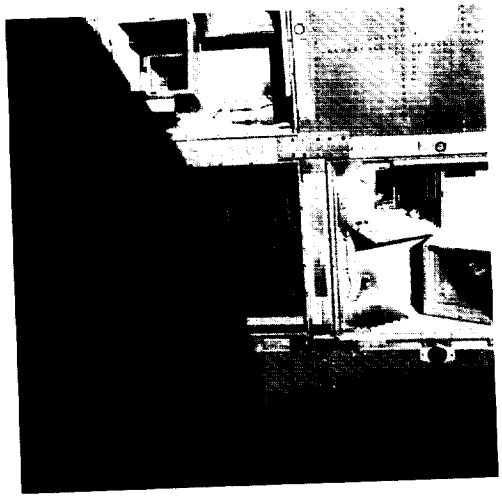

Figure 592
Photo No. S32-75-062
Dup. Neg. No.: L90-10368
LISAR NO.: EL-1994-00673
Photo Credit: JSC
Photo Date: 1/12/90
Location: In Flight
Subject: In-Flight Survey of Tray H7

***Figure 593 (Postflight).*** The experiment appears to have no physical damage. This photograph was taken from the cargo bay access hatch of the orbiter during postlanding operations at the Dryden Flight Research Center. Note the discolorations on the structure of the LDEF, the tray flanges, and the tray clamp white dots and the variation of discoloration with proximity to the thermal panel vents. The black thermal coating on the passive part of the experiment appears unchanged, while the black thermal coating on the active part of the experiment appears dark gray. The surfaces of the Kapton film specimens of the passive experiment appear to have changed from specular to diffuse after exposure to the space environment.

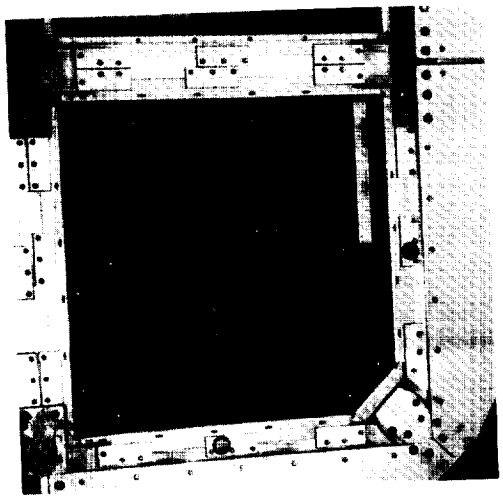

Figure 593
Photo No.: S32(S)-288
Dup. Neg. No.: L92-21195
LISAR NO.: EL-1994-00075
Photo Credit: JSC
Photo Date: 1/22/90
Location: Shuttle Cargo Bay at Dryden
Subject: Postflight Survey of Tray H7

***Figure 594 (Postflight).*** Experiment AO133 appears to have no physical damage. A light tan discoloration is visible on the left and lower flanges of the experiment tray and also on the unpainted aluminum filler to the left of the passive part of the experiment. A darker stain has discolored the lower corners of the tray structure. The black thermal coating on the active part of the experiment has changed from flat black to dark gray. The coating on the passive part of the experiment appears less degraded. The exposed surfaces of the Kapton film specimens in both the active and passive parts of the experiment appear to have changed from specular to diffuse because of exposure to the space environment.

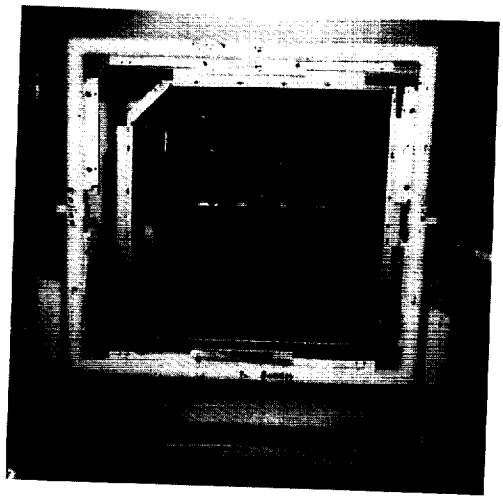

Figure 594
Photo No.: KSC-390C-1990.01
Dup. Neg. No.: L91-15659
LISAR NO.: EL-1994-00295
Photo Credit: KSC
Photo Date: 3/15/90
Location: KSC SAEF II
Subject: Postflight Survey of Tray H7

***Figure 595 (Postflight).*** This photograph is of the upper left one-fourth of the tray. The experiment is intact, but the surface appears lighter than in preflight conditions. Light reflections from some underlying surfaces are visible.

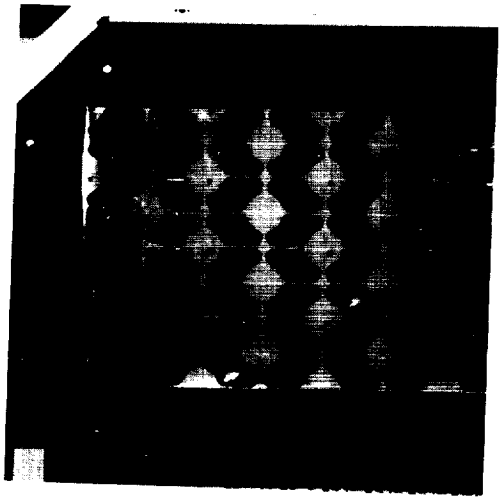

Figure 595
Photo No.: KSC-390C-1990.03
Dup. Neg. No.: L91-15642
LISAR NO.: EL-1994-00409
Photo Credit: KSC
Photo Date: 3/15/90
Location: KSC SAEF II
Subject: Postflight Detail of Upper Left of Tray H7

***Figure 596 (Postflight).*** This photograph is of the upper right one-fourth of the tray. The experiment is intact, but the surface appears lighter than in preflight conditions. Light reflections from some underlying surfaces are visible.

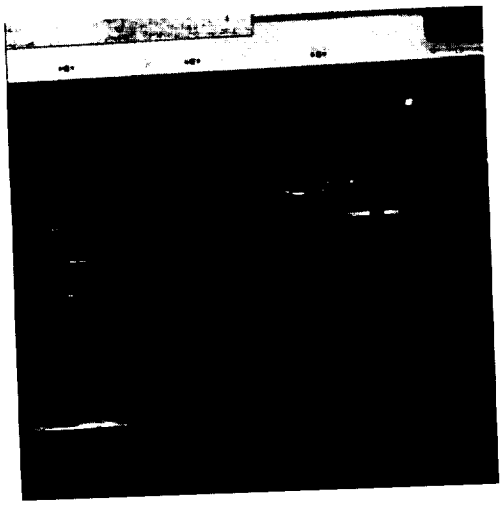

Figure 596
Photo No.: KSC-390C-1990.04
Dup. Neg. No.: L91-15643
LISAR NO.: EL-1994-00410
Photo Credit: KSC
Photo Date: 3/15/90
Location: KSC SAEF II
Subject: Postflight Detail of Upper Right of Tray H7

***Figure 597 (Postflight).*** This photograph is of the lower left one-fourth of the tray. The experiment is intact. The color of the test specimens does not appear as dark as in preflight.

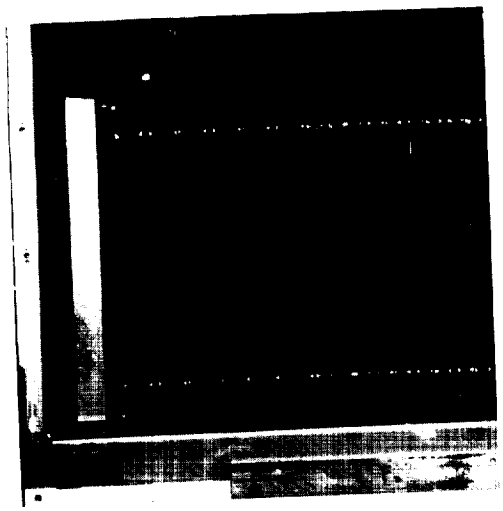

Figure 597
Photo No.: KSC-390C-1990.05
Dup. Neg. No.: L91-15644
LISAR NO.: EL-1994-00411
Photo Credit: KSC
Photo Date: 3/15/90
Location: KSC SAEF II
Subject: Postflight Detail of Lower Left of Tray H7

***Figure 598 (Postflight).*** This photograph is of the lower right one-fourth of the tray. The experiment is intact, but the test specimens are not as dark as in preflight. Light reflections from some underlying surfaces are visible.

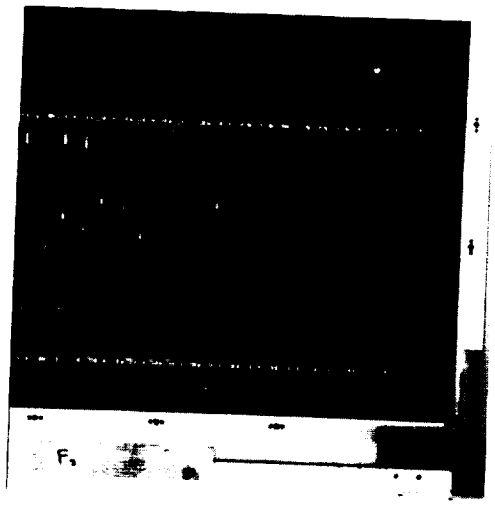

Figure 598
Photo No.: KSC-390C-1990.06
Dup. Neg. No.: L91-15645
LISAR NO.: EL-1994-00412
Photo Credit: KSC
Photo Date: 3/15/90
Location: KSC SAEF II
Subject: Postflight Detail of Lower Right of Tray H7

## Tray H9

Interstellar Gas Experiment (AO038)

JSC

University of Bern

Trays: E12, F6, H6, and H9

Experiment AO038 was designed to collect and isotopically analyze the noble gases in the particle wind that is formed as the local interstellar medium moves through the inner solar system.

***Figure 599 (Preflight).*** The prelaunch photograph of the hardware for experiment AO038 shows the orientation of two experiment canister housings that were mounted in a 12-in-deep tray. The experiment utilized seven canisters that contained high-purity beryllium copper collecting foils. Three canisters were located in peripheral trays and four canisters were located in trays on the space end of the LDEF. The aluminum housing covers, which were removed prior to flight, protected experiment components from damage and large particle contamination during ground handling. The tray was painted white to provide the necessary thermal control.

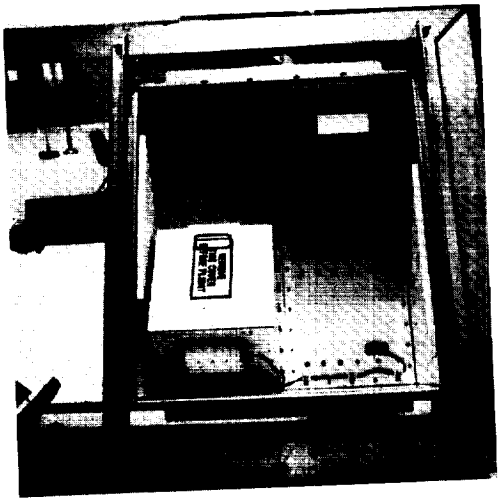

Figure 599
Photo No.: KSC-384C-538.06
Dup. Neg. No.: L89-4418
LISAR NO.: EL-1994-00042
Photo Credit: KSC
Photo Date: 1/30/84
Location: KSC SAEF II
Subject: Preflight Survey of Tray H9

***Figure 600 (In Flight).*** A very light contamination stain is present on the experiment tray flanges and on most of the visible structure of the LDEF. The exception is a darker stain on the structure adjacent to thermal panels that provided venting for the interior. Both paint dots are heavily coated with the brown contamination stain. The color of the white thermal control paint now varies from off-white to dark brown with areas of concentrated brown discoloration. A beryllium copper collector foil is clearly visible in the lower left canister housing as are the baffles. Reflected light from the fine wire mesh grid is visible near the top of the canister housing. Because of an experiment system malfunction, the canister collector foils that are visible were exposed for the total mission.

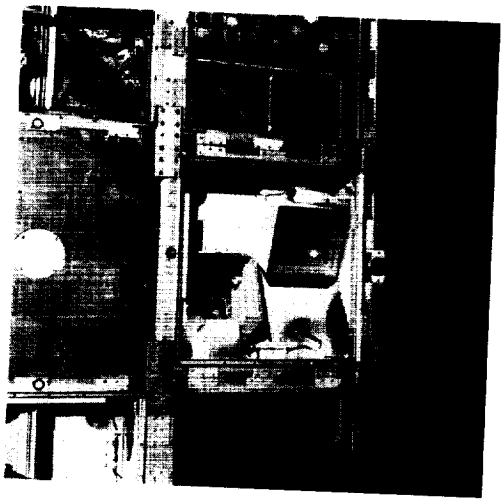

Figure 600
Photo No.: S32-75-061
Dup. Neg. No.: L90-10367
LISAR NO.: EL-1994-00672
Photo Credit: JSC
Photo Date: 1/12/90
Location: In Flight
Subject: In-Flight View of Tray H9

***Figure 601 (Postflight).*** This photograph was taken from the cargo bay access hatch of the orbiter during postlanding operations at the Dryden Flight Research Center. Note the discolorations on the structure of the LDEF, tray flanges, and tray clamp white dots and the variation of discoloration with proximity to the thermal panel vents. The color of the white thermal control paint now varies from off-white to dark brown with areas of concentrated discoloration. A beryllium copper collector foil is clearly visible in the upper right canister housing as are the baffles. Reflected light from the fine wire mesh grid is visible near the top of the canister housing.

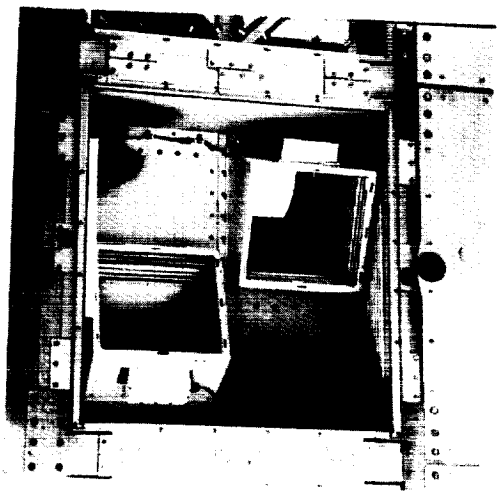

Figure 601
Photo No.: S32(S)-286
Dup. Neg. No.: L92-21193
LISAR NO.: EL-1994-00074
Photo Credit: JSC
Photo Date: 1/22/90
Location: Shuttle Cargo Bay at Dryden
Subject: Postflight Survey of Tray H9

***Figure 602 (Postflight).*** The brown stains are still very prominent and appear to be the same as in the in-flight photograph. The openings in the baseplate for the grid voltage cable connector mounts are thought to be the source of the darker brown stains around the connectors. The covers were installed on the canister housings to protect the space-exposed hardware. The contamination stain provides an outline of tray clamp block locations on the tray flanges.

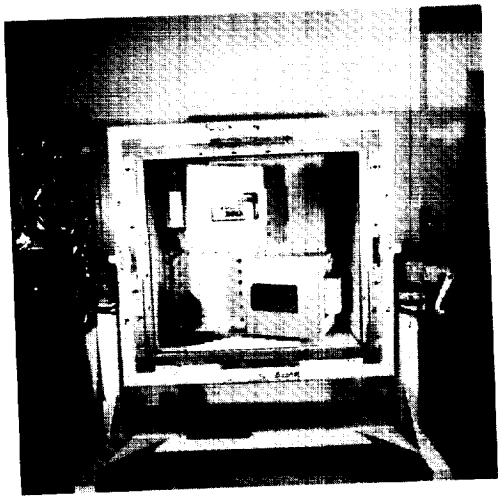

Figure 602
Photo No.: KSC-390C-1636.10
Dup. Neg. No.: L91-11881
LISAR NO.: EL-1994-00214
Photo Credit: KSC
Photo Date: 3/6/90
Location: KSC SAEF II
Subject: Postflight Survey of Tray H9

***Figure 603 (Postflight).*** This photograph is of the upper left one-fourth of the tray. Note the discoloration on the tray around the canister. The cover was installed on the canister housing to protect the space-exposed hardware.

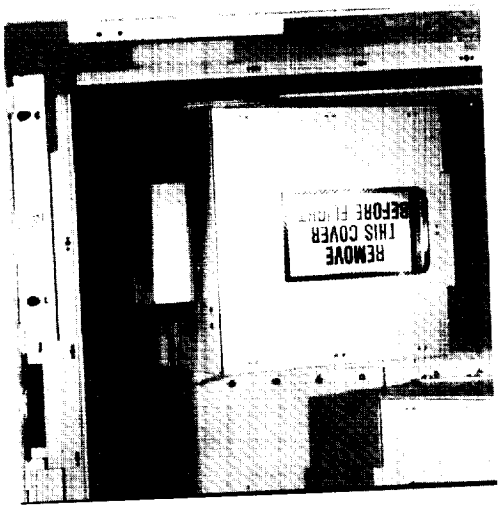


Figure 603
Photo No.: KSC-390C-1637.01
Dup. Neg. No.: L91-11912
LISAR NO.: EL-1994-00656
Photo Credit: KSC
Photo Date: 3/6/90
Location: KSC SAEF II
Subject: Postflight Detail of Upper Left of Tray H9

***Figure 604 (Postflight).*** This photograph is of the upper right one-fourth of the tray. Note the dark brown discoloration on the tray around the canister. A shadow of the canister is caused by the photographic lights. The cover was installed on the canister housing to protect the space-exposed hardware.

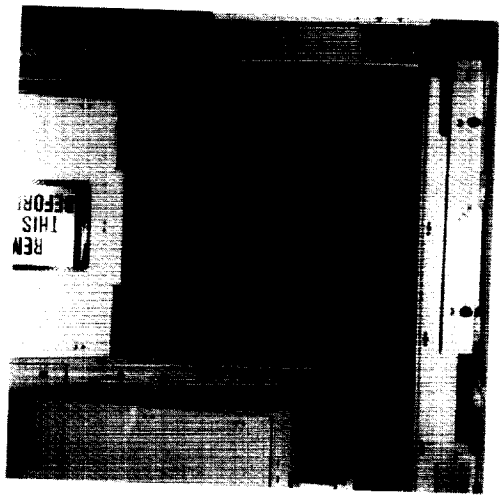

Figure 604
Photo No.: KSC-390C-1637.02
Dup. Neg. No.: L91-11913
LISAR NO.: EL-1994-00695
Photo Credit: KSC
Photo Date: 3/6/90
Location: KSC SAEF II
Subject: Postflight Detail of Upper Right of Tray H9

***Figure 605 (Postflight).*** This photograph is of the lower right one-fourth of the tray. Note the discoloration on the tray around the canister. Some photographic light shadows are present. The cover was installed on the canister housing to protect the space-exposed hardware.

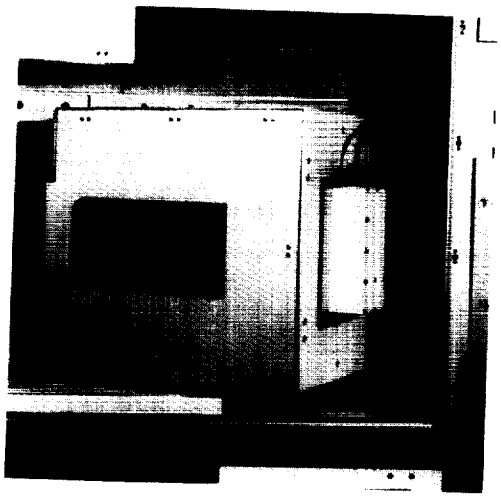

Figure 605
Photo No.: KSC-390C-1637.03
Dup. Neg. No.: L91-11914
LISAR NO.: EL-1994-00696
Photo Credit: KSC
Photo Date: 3/6/90
Location: KSC SAEF II
Subject: Postflight Detail of Lower Right of Tray H9

***Figure 606 (Postflight).*** This photograph is of the lower left one-fourth of the tray. Note the extreme brown discoloration on the tray around the grid voltage lead and plug. There are reflections of the lead in the bottom of the tray. The cover was installed on the canister housing to protect the space-exposed hardware.

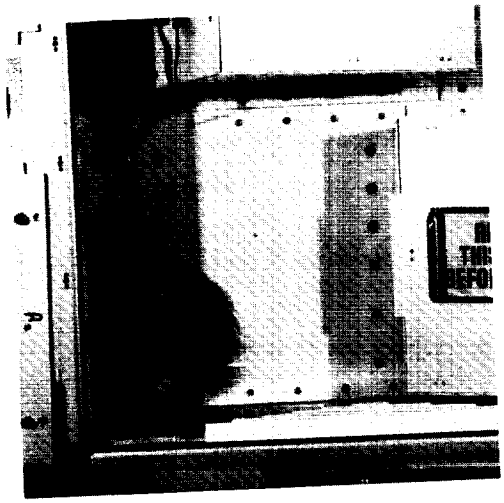

Figure 606
Photo No.: KSC-390C-1637.04
Dup. Neg. No.: L91-11915
LISAR NO.: EL-1994-00697
Photo Credit: KSC
Photo Date: 3/6/90
Location: KSC SAEF II
Subject: Postflight Detail of Lower Left of Tray H9

## Tray H11

Multiple Foil Microabrasion Package (MAP) (AO023)

University of Kent

Trays: C3, C9, D12, E6, and H11

The objective of this experiment was to capture micrometeoroids and space debris particles with multiple thin aluminum and brass foil arrays, which ranged in thickness from 1.5 μm to 30 μm. This experiment looked for size, velocity, composition, and distribution of solid particles in the near-Earth environment.

Interplanetary Dust Experiment (IDE) (AO201)

Institute for Space Science and Technology

NASA LaRC

North Carolina State University

Trays: B12, C3, C9, D6, G10, and H11

The objective of this experiment was to study interplanetary dust and obtain information about particle mass and velocity.

***Figure 607 (Preflight).*** Experiment AO023, which is located in the right half of the tray, is described in figure 230. Experiment AO201, which is located in the left half of the tray, is described in figure 211. The different colors on the IDE detectors are the reflection of one of the technicians and the surrounding area in the metallic, mirrorlike, surface.

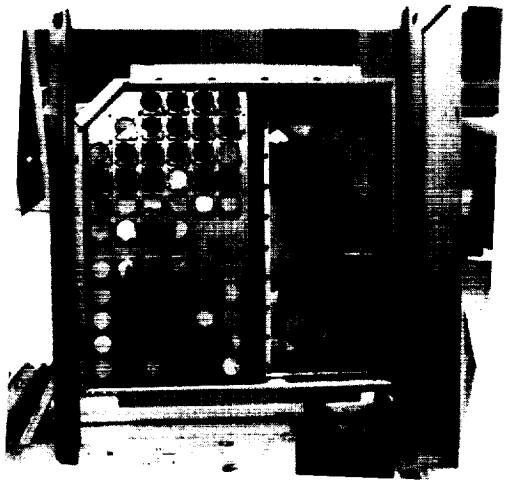

Figure 607
Photo No.: KSC-384C-8.04
Dup. Neg. No.: L84-6997
LISAR NO.: EL-1994-00321
Photo Credit: KSC
Photo Date: 1/10/84
Location: KSC SAEF II
Subject: Preflight Survey of Tray H11

***Figure 608 (In Flight).*** There is a brown stain on the tray structure and most aluminum surfaces of experiments. Note the discolorations on the structure of the LDEF, tray flanges, and tray clamp white dots and the variation of discoloration with proximity to the thermal panel vents. The colors in the mirrorlike surface of the detectors are a reflection of the sky and clouds. The dark spot on the detector in the third row from the top seems to be a flaw in the photograph since no damage was found in a postflight inspection.

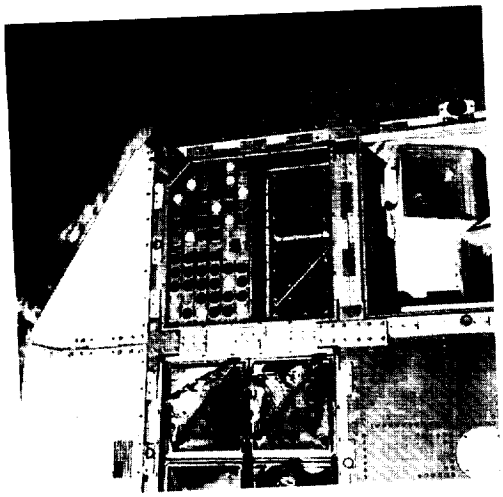

Figure 608
Photo No.: S32-75-060
Dup. Neg. No.: L90-10366
LISAR NO.: EL-1994-00671
Photo Credit: JSC
Photo Date: 1/12/90
Location: In Flight
Subject: In-Flight Survey of Tray H11

***Figure 609 (Postflight).*** This postlanding photograph was taken from the cargo bay access hatch of the orbiter during postlanding operations at the Dryden Flight Research Center. Note the discolorations on the structure of the LDEF, tray flanges, and tray clamp white dots and the variation of discoloration with proximity to the thermal panel vents. The colors in the mirror-like surface of the detectors are a reflection of the cargo bay liner of the orbiter.

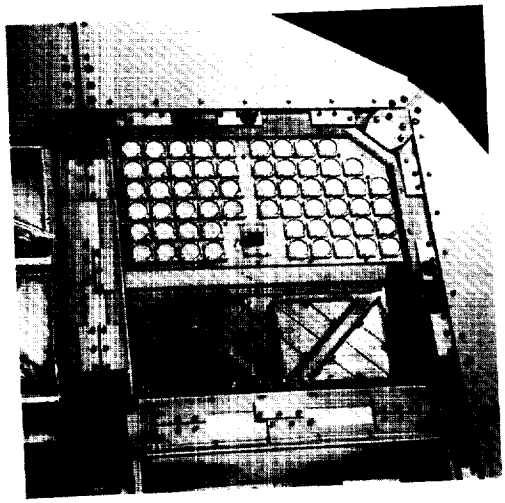

Figure 609
Photo No.: S32(S)-284
Dup. Neg. No.: L92-21191
LISAR NO.: EL-1994-00073
Photo Credit: JSC
Photo Date: 1/22/90
Location: Shuttle Cargo Bay at Dryden
Subject: Postflight Survey of Tray H11

***Figure 610 (Postflight).*** Both experiments appear intact. The colors in the mirrorlike surface of the detectors are reflections of the surrounding area. A dark spot on a detector in the third row from the top in the in-flight photograph was not found in a postflight inspection.

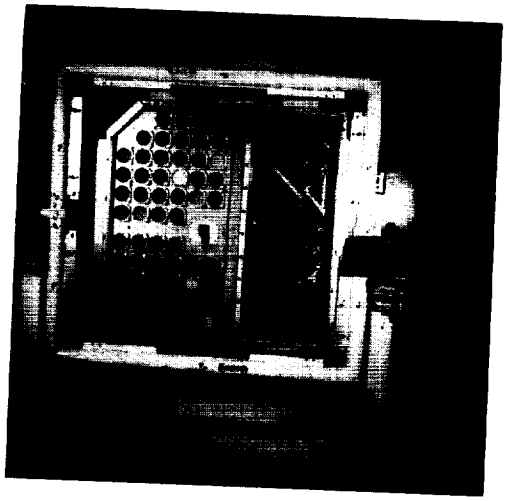

Figure 610
Photo No.: KSC-390C-2065.07
Dup. Neg. No.: L91-15678
LISAR NO.: EL-1994-00297
Photo Credit: KSC
Photo Date: 3/19/90
Location: KSC SAEF II
Subject: Postflight Survey of Tray H11

***Figure 611 (Postflight).*** This photograph is of the upper left one-fourth of the tray. The tray flanges, the sensor holders, and the base mounting plate all have a brown stain. There is a brown stain on the upper right edge of the sensor surfaces. Surroundings are reflected in the mirrorlike surfaces of the detectors.

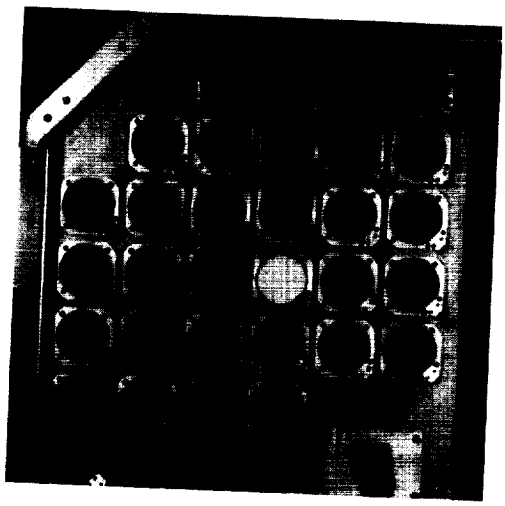

Figure 611
Photo No.: KSC-390C-2065.08
Dup. Neg. No.: L91-15679
LISAR NO.: EL-1994-00464
Photo Credit: KSC
Photo Date: 3/19/90
Location: KSC SAEF II
Subject: Postflight Detail of Upper Left of Tray H11

***Figure 612 (Postflight).*** This photograph is of the upper right one-fourth of the tray. The die-cast aluminum frames, fasteners, thermal isolation plate, and polished aluminum stop plate are moderately coated with a brown stain. The stain appears more concentrated in vicinities near adhesive bond joints.

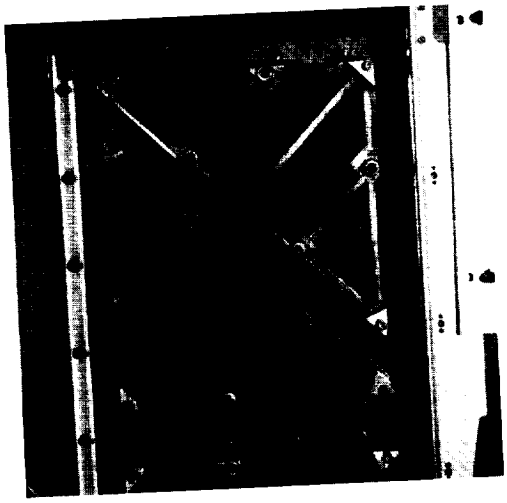

Figure 612
Photo No.: KSC-390C-2065.09
Dup. Neg. No.: L91-15680
LISAR NO.: EL-1994-00465
Photo Credit: KSC
Photo Date: 3/19/90
Location: KSC SAEF II
Subject: Postflight Detail of Upper Right of Tray H11

***Figure 613 (Postflight).*** This photograph is of the lower left one-fourth of the tray. The tray flanges, the sensor holders, and the base mounting plate all have a brown stain. There is a brown stain on the upper right edge of the sensor surfaces. Surroundings are reflected in the mirrorlike surfaces of the detectors.

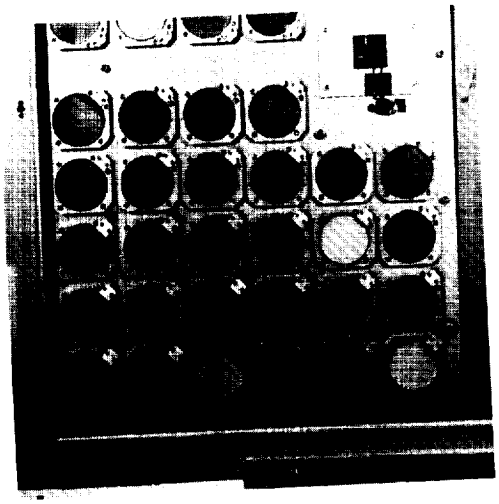

Figure 613
Photo No.: KSC-390C-2065.10
Dup. Neg. No.: L91-15681
LISAR NO.: EL-1994-00466
Photo Credit: KSC
Photo Date: 3/19/90
Location: KSC SAEF II
Subject: Postflight Detail of Lower Left of Tray H11

***Figure 614 (Postflight).*** This photograph is of the lower right one-fourth of the tray. The die-cast aluminum frames, fasteners, thermal isolation plate, and polished aluminum stop plate seem to be moderately coated with a brown stain. The stain appears to be more concentrated in vicinities near adhesive bond joints. There are photographic light reflections in the foil sensor surfaces.

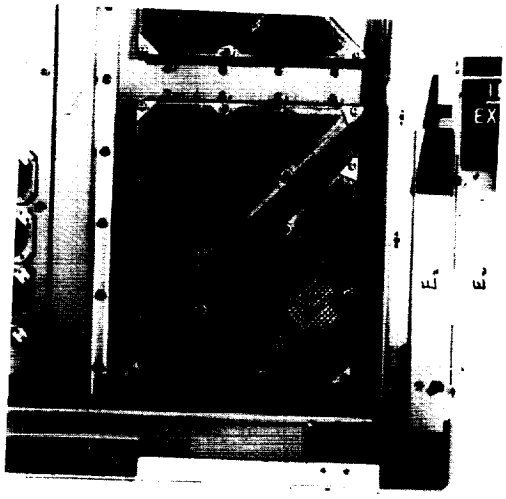

Figure 614
Photo No.: KSC-390C-2065.11
Dup. Neg. No.: L91-15682
LISAR NO.: EL-1994-00467
Photo Credit: KSC
Photo Date: 3/19/90
Location: KSC SAEF II
Subject: Postflight Detail of Lower Right of Tray H11

## Tray H12

Heavy Ions in Space (M0001)

Naval Research Laboratory

Trays: H3 and H12

The objective of this experiment was to provide a deep survey of intensely ionizing particles in low Earth orbit.

***Figure 615 (Preflight).*** The prelaunch photograph shows four experiment modules that were mounted in the experiment tray. An experiment module consisted of a multilayer thermal insulation blanket, a top stack of Lexan sheets for detecting low-energy ions, a honeycomb pressure cover, and the main stack of CR-39 sheets, which was used to detect cosmic rays. Three modules were identical, while the fourth module was divided into four smaller units that allowed pressure covers with a lower threshold to ion penetration. The top layer of the thermal blanket is a 5-mil Kapton film with an aluminum coating vapor deposited on the underside and an overcoat of Chemglaze II A-276 white paint on the exterior. The center section of the thermal blanket is constructed of approximately 22 layers of 1/4-mil perforated Mylar film with an aluminum coating vapor deposited on each side. The bottom layer of the thermal blanket is a 5-mil Kapton film with an aluminum coating vapor deposited on the side facing the Lexan detector stack sheet. A Dacron mesh (bridal veil) separator is placed between each aluminized Mylar layer of the core material. The frame around each of the four modules, which was a Z-shaped aluminum structure, was covered with a silvered Teflon film that was secured with 3M-Y966 acrylic transfer tape. The transfer tape on a silvered Teflon film was also used to attach the edges of the multilayer thermal blankets to the frame of the module.

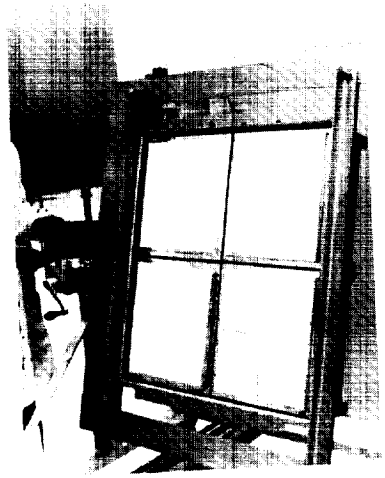

Figure 615
Photo No.: KSC-384C-331.06
Dup. Neg. No.: 84-7187
LISAR NO.: EL-1994-00646
Photo Credit: KSC
Photo Date: 1/24/84
Location: KSC SAEF II
Subject: Preflight Survey of Tray H12

***Figure 616 (In Flight).*** The multilayer thermal insulation blankets have extensive damage. The outside blanket surfaces that were originally white are now coated with a glossy dark brown stain. A light coating of the stain is on the tray flange adjacent to the American flag. Note the discolorations on the structure of the LDEF, tray flanges, and tray clamp white dots and the variation of discoloration with proximity to the thermal panel vents.

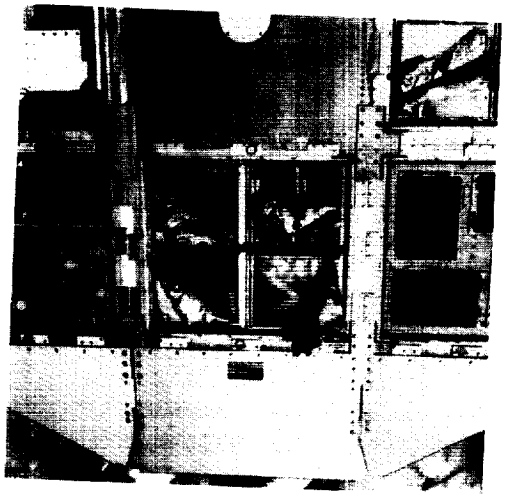

Figure 616
Photo No.: S32-75-067
Dup. Neg. No.: L90-10373
LISAR NO.: EL-1994-00676
Photo Credit: JSC
Photo Date: 1/12/90
Location: In Flight
Subject: In-Flight Survey of Tray H12

***Figure 617 (Postflight).*** This photograph of experiment M0001 was taken from the cargo bay access hatch of the orbiter during postlanding operations at the Dryden Flight Research Center. The photograph shows the extensive damage to the multilayer thermal blankets. The loose blankets appear to be more tightly rolled than in the in-flight photograph. The outside blanket surfaces that were originally painted white are now coated with a glossy dark brown stain.

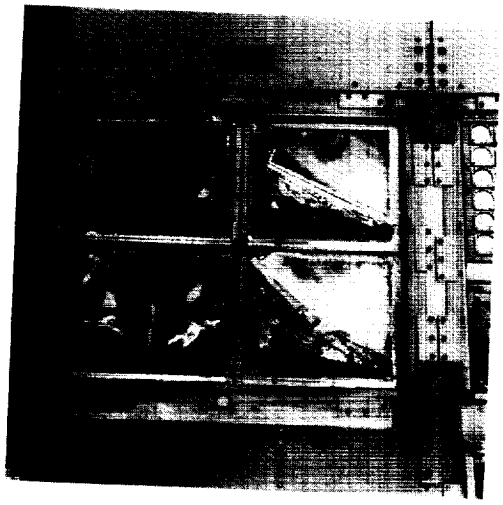

Figure 617
Photo No.: S32(S)-283
Dup. Neg. No.: L92-21190
LISAR NO.: EL-1994-00072
Photo Credit: JSC
Photo Date: 1/22/90
Location: Shuttle Cargo Bay at Dryden
Subject: Postflight Survey of Tray H12

***Figure 618 (Postflight).*** The postflight photograph shows the four experiment modules with multilayer thermal blankets that are severely degraded. Paint on the top layer, previously white, is now a glossy soft brown or tan. The thermal blankets apparently shrunk in flight, thus causing them to detach from the frame along two sides The tape used to attach the blanket to the structure failed in tension across the width of the tape, thus leaving tape on both the frame and the top layer of the thermal blanket. The thermal blankets on the three large modules have curled to expose the top Lexan layer of the detector stack beneath. The curled thermal blankets that protected the four smaller modules in the lower left now expose the 5-mil aluminized Kapton film pressure covers beneath. The damaged thermal blankets on the right side of the photograph reveal representative cross sections of the multilayer thermal blankets.

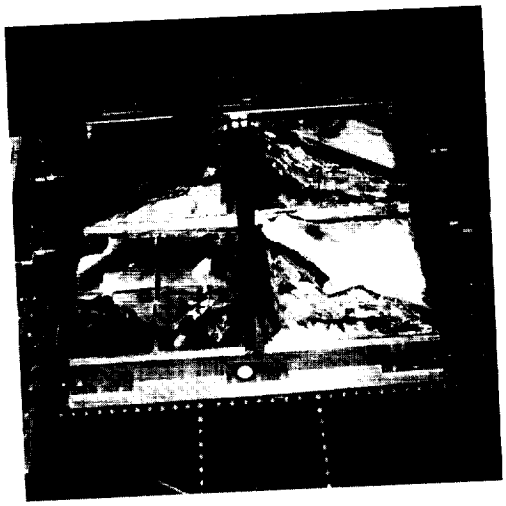

Figure 618
Photo No.: L90-1796
LISAR NO.: EL-1994-00380
Photo Credit: LaRC
Photo Date: 2/6/90
Location: KSC SAEF II
Subject: Postflight Survey of Tray H12

***Figure 619 (Postflight).*** This photograph is of the lower right one-fourth of the tray. The discolored and damaged thermal blanket is shown. A representative cross section of the blanket is visible.

Figure 619
Photo No.: KSC-390C-828.05
Dup. Neg. No.: L91-15548
LISAR NO.: EL-1994-00166
Photo Credit: KSC
Photo Date: 2/6/90
Location: KSC SAEF II
Subject: Postflight Detail of Lower Right of Tray H12

***Figure 620 (Postflight).*** This photograph is of the lower left one-fourth of the tray. The curled thermal blankets that protected the four smaller modules now expose the 5-mil aluminized Kapton film pressure covers beneath.

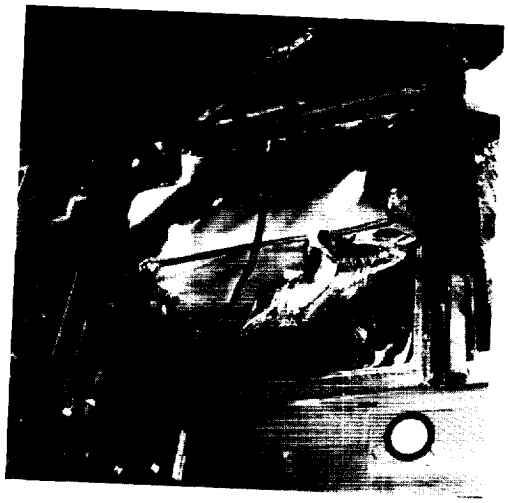

Figure 620
Photo No.: KSC-390C-828.06
Dup. Neg. No.: L91-15549
LISAR NO.: EL-1994-00167
Photo Credit: KSC
Photo Date: 2/6/90
Location: KSC SAEF II
Subject: Postflight Detail of Lower Left of Tray H12

***Figure 621 (Postflight).*** This photograph is of the upper left one-fourth of the tray. The damaged thermal blanket has curled to expose the top Lexan layer of the detector stack beneath.

Figure 621
Photo No.: KSC-390C-828.07
Dup. Neg. No.: L91-15550
LISAR NO.: EL-1994-00168
Photo Credit: KSC
Photo Date: 2/6/90
Location: KSC SAEF II
Subject: Postflight Detail of Upper Left of Tray H12

***Figure 622 (Postflight).*** This photograph is of the upper right one-fourth of the tray. The discolored and damaged thermal blanket is shown. A representative cross section of the blanket is visible.

Figure 622
Photo No.: KSC-390C-828.08
Dup. Neg. No.: L91-15551
LISAR NO.: EL-1994-00169
Photo Credit: KSC
Photo Date: 2/6/90
Location: KSC SAEF II
Subject: Postflight Detail of Upper Right of Tray H12

***Figure 623 (Postflight).*** This photograph shows a white card for comparison with the discolored thermal covers.

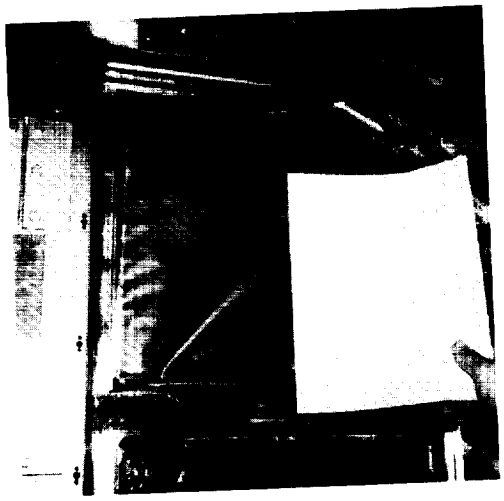

Figure 623
Photo No.: KSC-390C-829.02
Dup. Neg. No.: L91-15557
LISAR NO.: EL-1994-00283
Photo Credit: KSC
Photo Date: 2/6/90
Location: KSC SAEF II
Subject: Postflight Detail of Tray H12

# Postflight Photographs of Structural Elements Showing Circumferential and Lengthwise Variation of Discoloration

***Figure 624 (Postflight).*** This photograph shows longeron A between rows 12 and 1 with the Earth-facing end to the left. The side of tray A12 was adjacent to this longeron. Little if any contamination on the longeron is visible. Note the discoloration on the intercostal to the left. The edge of the thermal panel location is marked by a line of concentrated brown discoloration. This discoloration was the effect of internal venting. The area covered by the tray flange contrasts with the unshielded area of the intercostal.

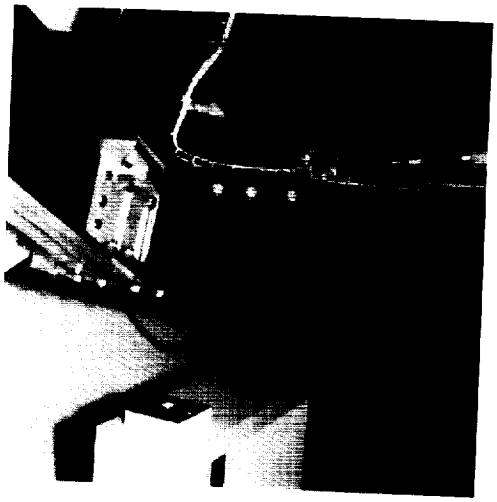

Figure 624
Photo No.: KSC-390C-2951.10
Dup. Neg. No.: L92-20490
LISAR NO.: EL-1994-00608
Photo Credit: KSC
Photo Date: 4/8/90
Location: SAEF II
Subject: Postflight Detail of Longeron A Between Rows 12 and 1

***Figure 625 (Postflight).*** Longeron B between rows 1 and 2 with the Earth-facing end to the left is shown in this photograph. The side of tray A1 was adjacent to this longeron. The light area on the longeron is a reflection off the intercostal end fitting. There is a distinct pattern of discoloration on the side of the longeron. The discoloration on the intercostal is washed out by lighting.

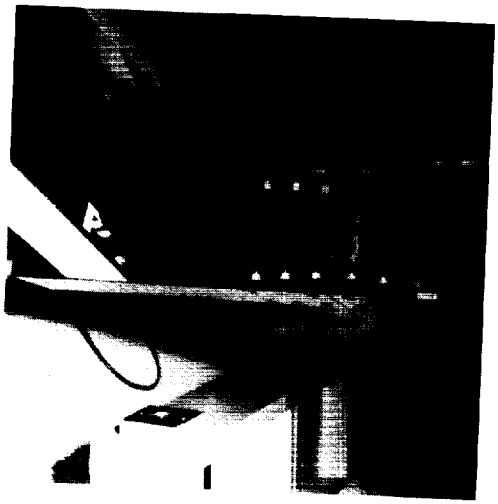

Figure 625
Photo No.: KSC-390C-2949.02
Dup. Neg. No.: L92-18257
LISAR NO.: EL-1994-00634
Photo Credit:
Location:
Subject: Postflight Detail of Longeron B Between Rows 1 and 2

***Figure 626 (Postflight).*** Longeron C between rows 2 and 3 with the Earth-facing end to the left is shown in this photograph. The side of tray A2 was adjacent to this longeron. The light area on the longeron is a reflection off the intercostal end fitting. There is no significant discoloration on the longeron or line of concentrated discoloration at the thermal panel edge location. The area covered by the tray flange contrasts with the unshielded area of the intercostal.

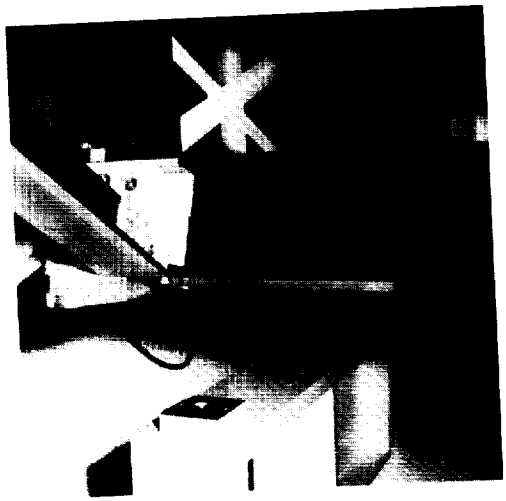

Figure 626
Photo No.: KSC-390C-2948.10
Dup. Neg. No.: L92-18590
LISAR NO.: EL-1994-00633
Photo Credit:
Location:
Subject: Postflight Detail of Longeron C Between Rows 2 and 3

***Figure 627 (Postflight).*** Longeron D between rows 3 and 4 with the Earth-facing end to the left is shown in this photograph. The side of tray A3 was adjacent to this longeron. The light area on the longeron is a reflection off the intercostal end fitting. There is no significant discoloration on the longeron or line of concentrated discoloration at the thermal panel edge location. The area covered by the tray flange contrasts with the unshielded area of the intercostal.

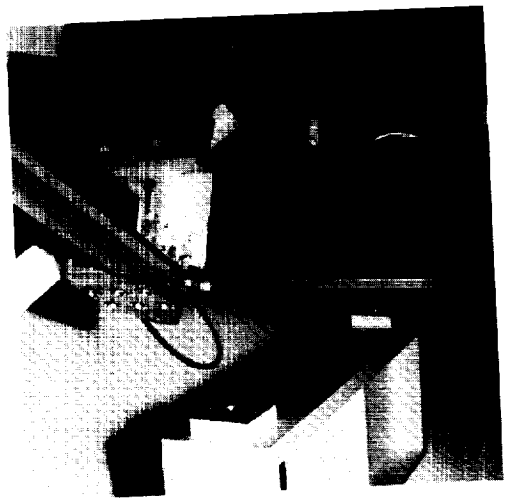

Figure 627
Photo No.: KSC-390C-2945.12
Dup. Neg. No.: L92-18556
LISAR NO.: EL-1994-00632
Photo Credit:
Location:
Subject: Postflight Detail of Longeron D Between Rows 3 and 4

***Figure 628 (Postflight).*** This photograph shows longeron E between rows 4 and 5 with the Earth-facing end to the left. The side of tray A4 was adjacent to this longeron. The considerable area of light on the longeron is a reflection off the intercostal end fitting. There is no significant discoloration on the longeron or line of concentrated discoloration at the thermal panel edge location. The area covered by the tray flange contrasts with the unshielded area of the intercostal.

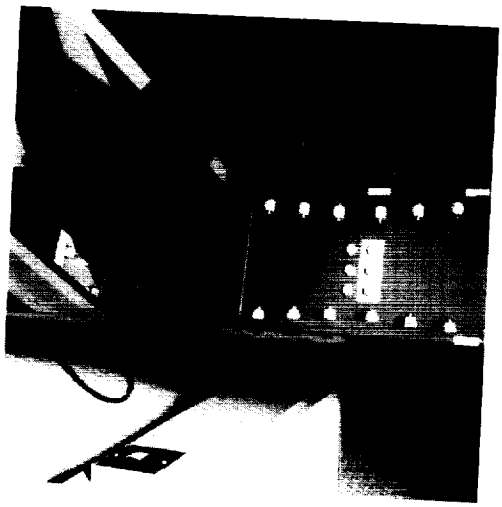

Figure 628
Photo No.: KSC-390C-2945.09
Dup. Neg. No.: L92-18553
LISAR NO.: EL-1994-00631
Photo Credit:
Location:
Subject: Postflight Detail of Longeron E Between Rows 4 and 5

***Figure 629 (Postflight).*** This photograph shows longeron F between rows 5 and 6 with the Earth-facing end to the left. The side of tray A5 was adjacent to this longeron. The light area on the longeron is a reflection off the intercostal end fitting. There is no significant discoloration on the longeron. There is no line of concentrated discoloration at the thermal panel edge location. The area covered by the tray flange contrasts with the unshielded area of the intercostal.

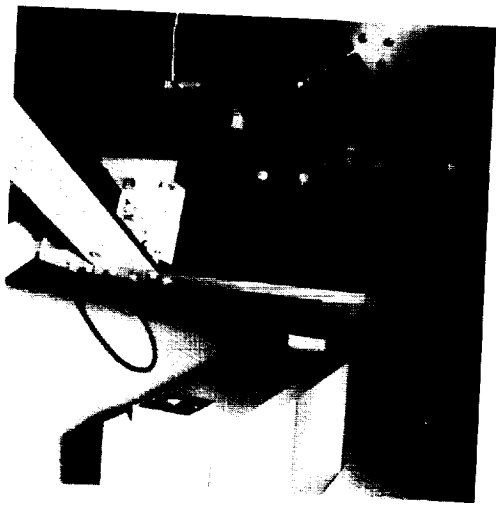

Figure 629
Photo No.: KSC-390C-2942.09
Dup. Neg. No.: L92-18517
LISAR NO.: EL-1994-00630
Photo Credit:
Location:
Subject: Postflight Detail of Longeron F Between Rows 5 and 6

***Figure 630 (Postflight).*** This photograph shows longeron G between rows 6 and 7 with the Earth-facing end to the left. The side of tray A6 was adjacent to this longeron. There is no visible discoloration on the longeron or line of concentrated discoloration at the thermal panel edge location. The area covered by the tray flange contrasts with the unshielded area of the intercostal.

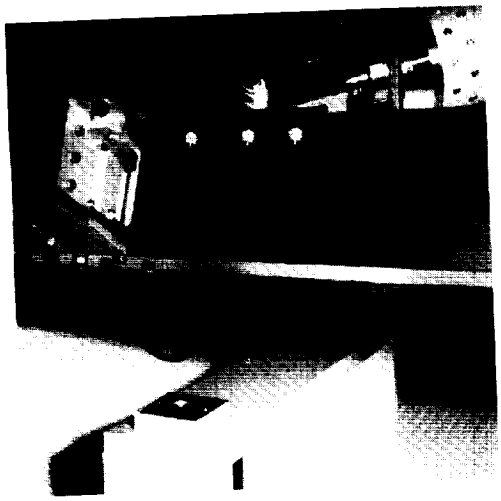

Figure 630
Photo No.: KSC-390C-2942.06
Dup. Neg. No.: L92-18514
LISAR NO.: EL-1994-00629
Photo Credit:
Location:
Subject: Postflight Detail of Longeron G Between Rows 6 and 7

***Figure 631 (Postflight).*** Longeron H between rows 7 and 8 with the Earth-facing end to the left is shown in this photograph. The side of tray A7 was adjacent to this longeron. The pattern of light on the longeron is a reflection off the intercostal end fitting. There is no significant discoloration on the longeron. The edge of the thermal panel location is marked by a line of concentrated brown discoloration. This was the effect of internal venting. The area covered by the tray flange contrasts with the unshielded area of the intercostal.

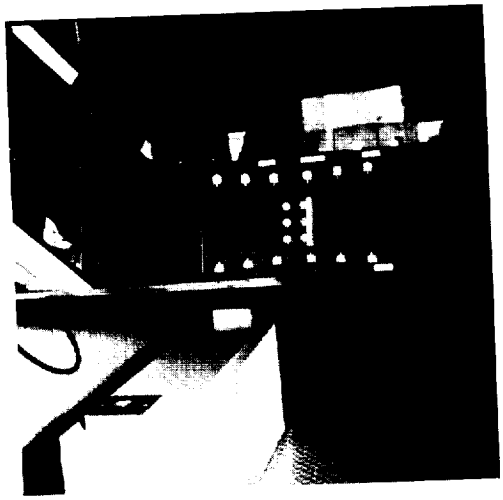

Figure 631
Photo No.: KSC-390C-2939.06
Dup. Neg. No.: L92-18479
LISAR NO.: EL-1994-00628
Photo Credit:
Location:
Subject: Postflight Detail of Longeron H Between Rows 7 and 8

***Figure 632 (Postflight).*** Longeron I between rows 8 and 9 with the Earth-facing end to the left is shown in this photograph. The side of tray A8 was adjacent to this longeron. There is a slight discoloration on the longeron. The edge of the thermal panel location is marked by a line of concentrated brown discoloration. This discoloration was the effect of internal venting. The area covered by the tray flange contrasts with the unshielded area of the intercostal.

Figure 632
Photo No.: KSC-390C-2939.03
Dup. Neg. No.: L92-18476
LISAR NO.: EL-1994-00627
Photo Credit:
Location:
Subject: Postflight Detail of Longeron I Between Rows 8 and 9

***Figure 633 (Postflight).*** This photograph shows longeron J between rows 9 and 10 with the Earth-facing end to the left. The side of tray A9 was adjacent to this longeron. There is some discoloration on the longeron. The edge of the thermal panel location is marked by a line of concentrated brown discoloration. This discoloration was the effect of internal venting. The area covered by the tray flange contrasts with the unshielded area of the intercostal.

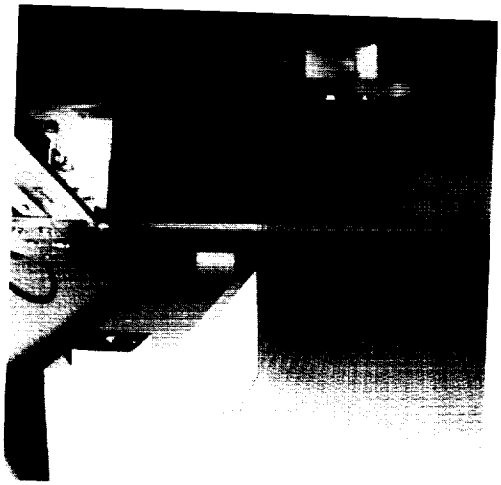

Figure 633
Photo No.: KSC-390C-2936.03
Dup. Neg. No.: L92-18440
LISAR NO.: EL-1994-00626
Photo Credit:
Location:
Subject: Postflight Detail of Longeron J Between Rows 9 and 10

***Figure 634 (Postflight).*** Longeron K between rows 10 and 11 with the Earth-facing end to the left is shown in this photograph. The side of tray A10 was adjacent to this longeron. There are areas of heavy discoloration on the longeron. This pattern of discoloration was the heaviest on longeron K. The edge of the thermal panel location is marked by a line of concentrated brown discoloration on the intercostal. This discoloration was the effect of internal venting. The area covered by the tray flange contrasts with the unshielded area of the intercostal.

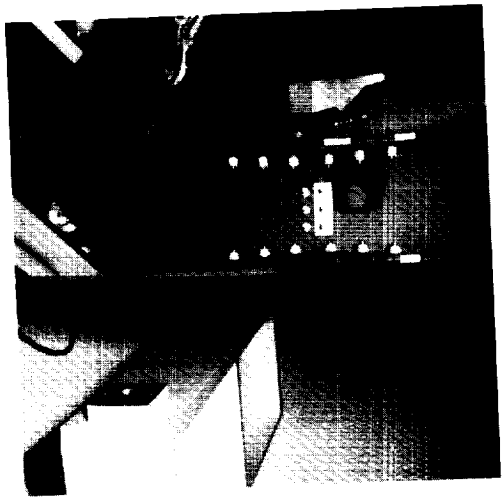

Figure 634
Photo No.: KSC-390C-2935.11
Dup. Neg. No.: L92-18436
LISAR NO.: EL-1994-00625
Photo Credit:
Location:
Subject: Postflight Detail of Longeron K Between Rows 10 and 11

***Figure 635 (Postflight).*** This photograph shows longeron L between rows 11 and 12 with the Earth-facing end to the left. The side of tray A11 was adjacent to this longeron. There are small areas of heavy discoloration on the longeron. The edge of the thermal panel location is marked by a line of concentrated brown discoloration on the intercostal. This discoloration was the effect of internal venting. The area covered by the tray flange contrasts with the unshielded area of the intercostal.

No photograph was taken of longeron A between rows 12 and 1 with the Earth-facing end to the right.

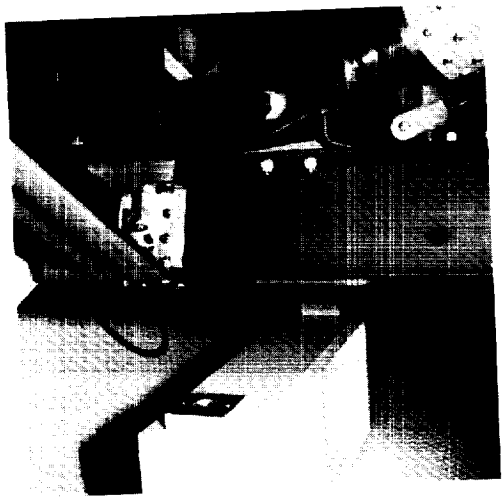

Figure 635
Photo No.: KSC-390C-2952.02
Dup. Neg. No.: L92-20494
LISAR NO.: EL-1994-00609
Photo Credit:
Location:
Subject: Postflight Detail of Longeron L Between Rows 11 and 12

***Figure 636 (Postflight).*** This photograph shows longeron B between rows 1 and 2 with the Earth-facing end to the right. The side of tray A2 was adjacent to this longeron. The pattern of light on the longeron is a reflection off the intercostal end fitting. There is no visible discoloration on the longeron or line of concentrated discoloration at the thermal panel edge location. The area covered by the tray flange contrasts with the unshielded area of the intercostal.

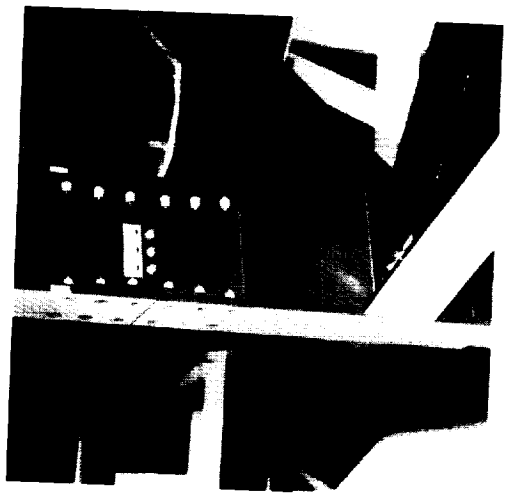

Figure 636
Photo No.: KSC-390C-3465.11
Dup. Neg. No. L92-20095
LISAR NO.: EL-1994-00584
Photo Credit: KSC
Photo Date: 4/20/90
Location: SAEF II
Subject: Postflight Detail of Longeron B Between Rows 1 and 2

***Figure 637 (Postflight).*** Longeron C between rows 2 and 3 with the Earth-facing end to the right is shown in this photograph. The side of tray A3 was adjacent to this longeron. The pattern of light on the longeron is a reflection off the intercostal end fitting. There is no visible discoloration on the longeron or line of concentrated discoloration at the thermal panel edge location. The area covered by the tray flange contrasts with the unshielded area of the intercostal and longeron.

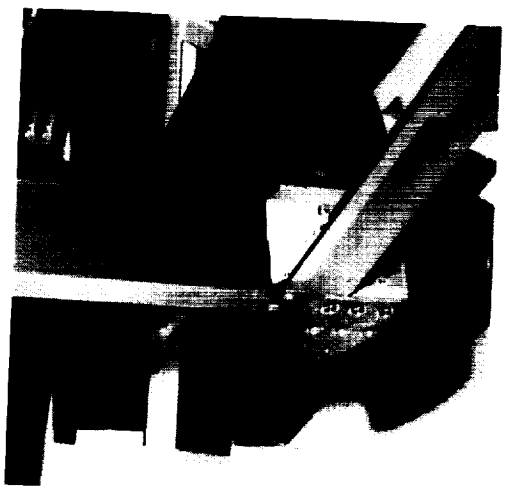

Figure 637
Photo No.: KSC-390C-3465.10
Dup. Neg. No. L92-20094
LISAR NO.: EL-1994-00583
Photo Credit: KSC
Photo Date: 4/20/90
Location: SAEF II
Subject: Postflight Detail of Longeron C Between Rows 2 and 3

***Figure 638 (Postflight).*** Longeron D between rows 3 and 4 with the Earth-facing end to the right is shown in this photograph. The side of tray A4 was adjacent to this longeron. There is no visible discoloration on the longeron. There is no line of concentrated discoloration at the thermal panel edge location. The area covered by the tray flange contrasts with the unshielded area of the intercostal.

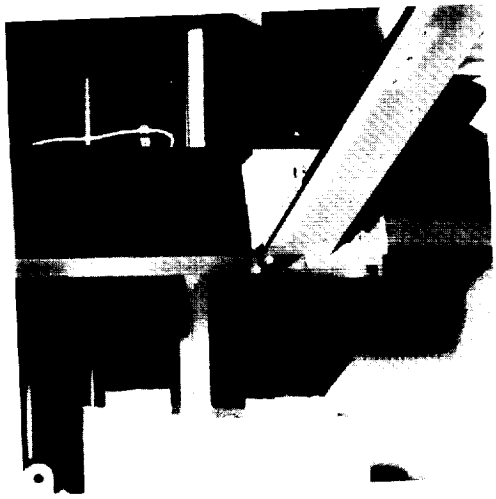

Figure 638
Photo No.: KSC-390C-3462.08
Dup. Neg. No. L92-20056
LISAR NO.: EL-1994-00582
Photo Credit: KSC
Photo Date: 4/20/90
Location: SAEF II
Subject: Postflight Detail of Longeron D Between Rows 3 and 4

***Figure 639 (Postflight).*** This photograph shows longeron E between rows 4 and 5 with the Earth-facing end to the right. The side of tray A5 was adjacent to this longeron. The pattern of light on the longeron is a reflection off the intercostal end fitting. There is a discoloration on the longeron. There is no line of concentrated discoloration at the thermal panel edge location. The area covered by the tray flange contrasts with the unshielded area of the intercostal.

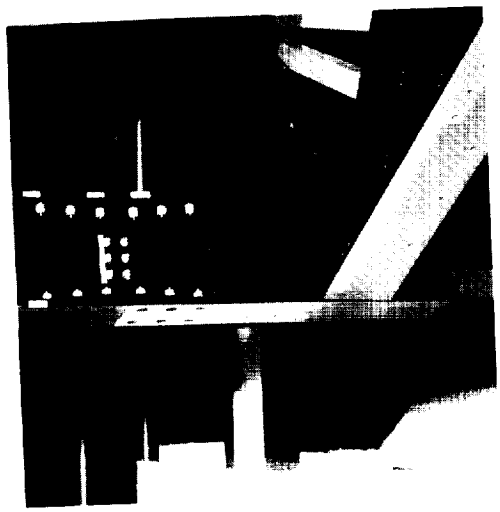

Figure 639
Photo No.: KSC-390C-3462.07
Dup. Neg. No. L92-20055
LISAR NO.: EL-1994-00581
Photo Credit: KSC
Photo Date: 4/20/90
Location: SAEF II
Subject: Postflight Detail of Longeron E Between Rows 4 and 5

***Figure 640 (Postflight).*** This photograph shows longeron F between rows 5 and 6 with the Earth-facing end to the right. The side of tray A6 was adjacent to this longeron. There is a heavy and distinct pattern of discoloration on the longeron. Note the distinct pattern of the bolts. There is no line of concentrated discoloration at the thermal panel edge location. The area covered by the tray flange contrasts with the unshielded area of the intercostal.

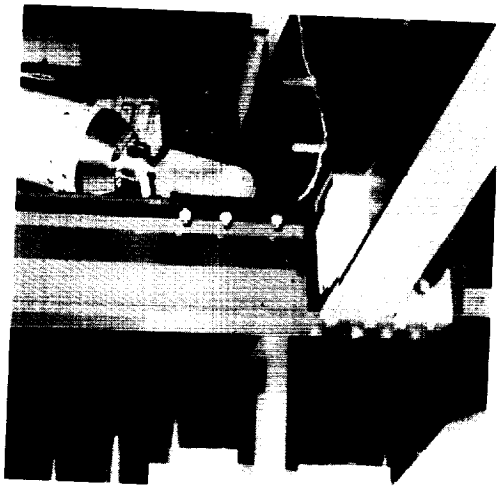

Figure 640
Photo No.: KSC-390C-3459.05
Dup. Neg. No. L92-19138
LISAR NO.: EL-1994-00548
Photo Credit: KSC
Photo Date: 4/20/90
Location: SAEF II
Subject: Postflight Detail of Longeron F Between Rows 5 and 6

***Figure 641 (Postflight).*** This photograph shows longeron G between rows 6 and 7 with the Earth-facing end to the right. The side of tray A7 was adjacent to this longeron. There is a small pattern of discoloration on the longeron and on the diagonal structural member fitting. There is a distinct line of concentrated discoloration at the thermal panel edge location. This discoloration was the effect of internal venting. The area covered by the tray flange contrasts with the unshielded area of the intercostal.

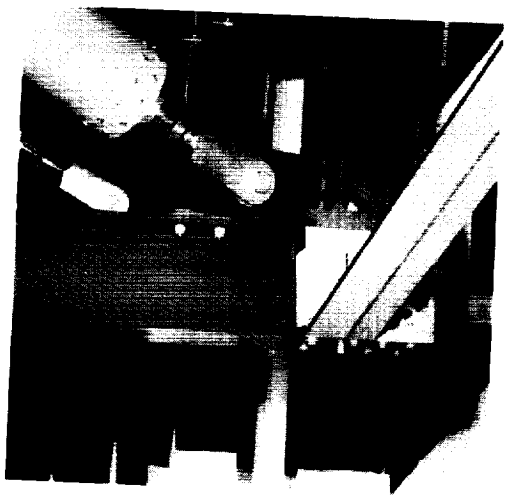

Figure 641
Photo No. KSC-390C-3459.04
Dup. Neg. No. L92-19137
LISAR NO.: EL-1994-00577
Photo Credit: KSC
Photo Date: 4/20/90
Location: SAEF II
Subject: Postflight Detail of Longeron G Between Rows 6 and 7

***Figure 642 (Postflight).*** Longeron H between rows 7 and 8 with the Earth-facing end to the right is shown in this photograph. The side of tray A8 was adjacent to this longeron. There is a pattern of discoloration on the longeron. There is a distinct line of concentrated discoloration at the thermal panel edge location. The area covered by the tray flange contrasts with the unshielded area of the intercostal.

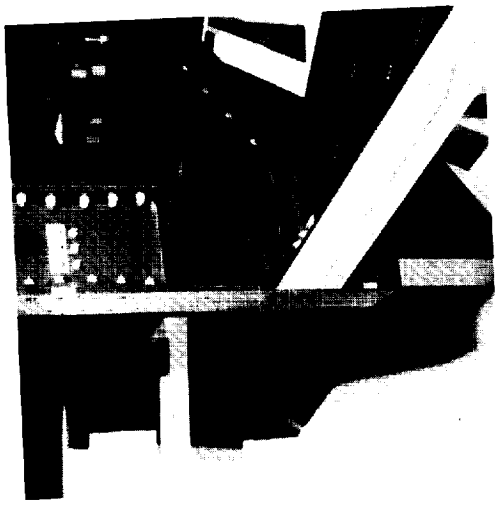

Figure 642
Photo No.: KSC-390C-3455.12
Dup. Neg. No. L92-19097
LISAR NO.: EL-1994-00615
Photo Credit: KSC
Photo Date: 4/20/90
Location: SAEF II
Subject: Postflight Detail of Longeron H Between Rows 7 and 8

***Figure 643 (Postflight).*** Longeron I between rows 8 and 9 with the Earth-facing end to the right is shown in this photograph.The side of tray A9 was adjacent to this longeron. There is a large pattern of discoloration on the longeron. There is a distinct line of concentrated discoloration at the thermal panel edge location. This discoloration was the effect of internal venting. The area covered by the tray flange contrasts with the unshielded area of the intercostal.

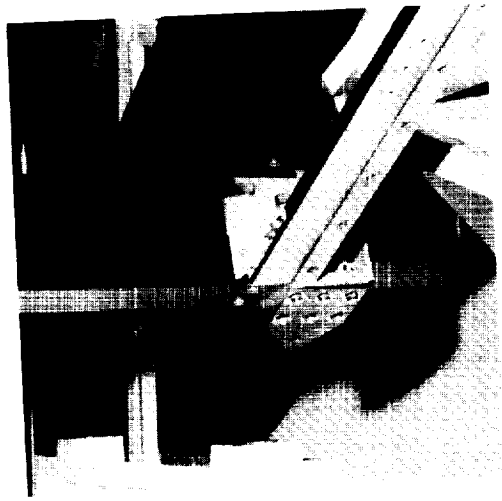

Figure 643
Photo No.: KSC-390C-3455.11
Dup. Neg. No. L92-19096
LISAR NO.: EL-1994-00614
Photo Credit: KSC
Photo Date: 4/20/90
Location: SAEF II
Subject: Postflight Detail of Longeron I Between Rows 8 and 9

***Figure 644 (Postflight).*** Longeron J between rows 9 and 10 with the Earth-facing end to the right is shown in this photograph. The side of tray A10 was adjacent to this longeron. There is little if any discoloration on the longeron. There is a distinct line of discoloration at the thermal panel edge location. The area covered by the tray flange contrasts with the unshielded area of the intercostal.

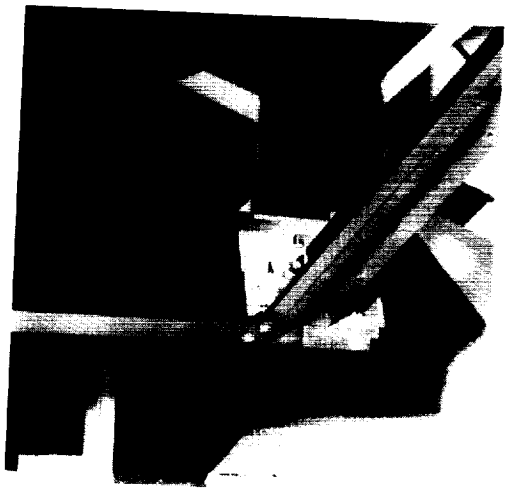

Figure 644
Photo No.: KSC-390C-3452.09
Dup. Neg. No. L92-19058
LISAR NO.: EL-1994-00722
Photo Credit: KSC
Photo Date: 4/20/90
Location: SAEF II
Subject: Postflight Detail of Longeron J Between Rows 9 and 10

***Figure 645 (Postflight).*** This photograph shows longeron K between rows 10 and 11 with the Earth-facing end to the right. The side of tray A11 was adjacent to this longeron. There is little if any discoloration on the longeron. There is a distinct line of discoloration at the thermal panel edge location. The area covered by the tray flange contrasts with the unshielded area of the intercostal.

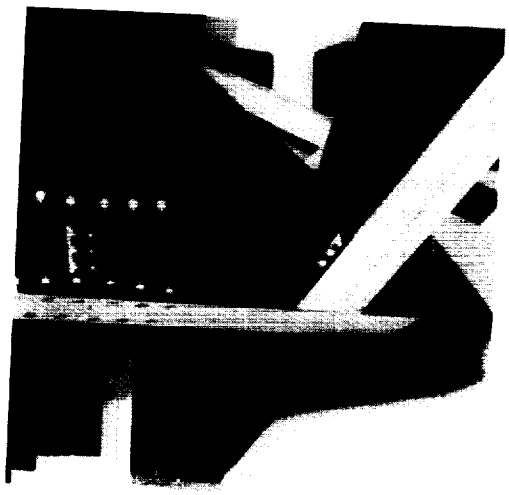

Figure 645
Photo No.: KSC-390C-3452.08
Dup. Neg. No. L92-19057
LISAR NO.: EL-1994-00721
Photo Credit: KSC
Photo Date: 4/20/90
Location: SAEF II
Subject: Postflight Detail of Longeron K Between Rows 10 and 11

***Figure 646 (Postflight).*** This photograph shows longeron L between rows 11 and 12 with the Earth-facing end to the right. The side of tray A12 was adjacent to this longeron. There is no discoloration on the longeron. There is no line of concentrated discoloration at the thermal panel edge location. The area covered by the tray flange contrasts with the unshielded area of the intercostal.

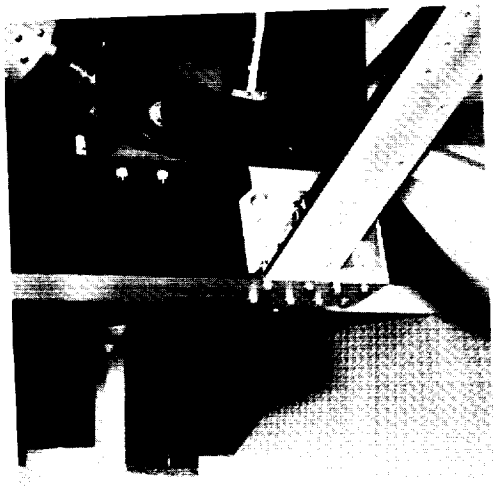

Figure 646
Photo No.: KSC-390C-3469.02
Dup. Neg. No.: L92-3731
LISAR NO.: EL-1994-00585
Photo Credit: KSC
Photo Date: 4/20/90
Location: SAEF II
Subject: Postflight Detail of Longeron L Between Rows 11 and 12

***Figure 647 (Postflight).*** Tray A1 was adjacent to this part (left intercostal of bay A) of longeron B. Longeron B (Earth-facing end to left) was selected because of the distinct patterns on the longeron web. There is a significant and well-defined pattern of discoloration near the left intercostal.

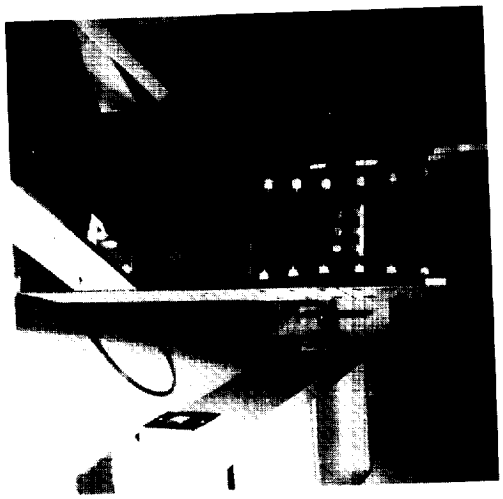

Figure 647
Photo No.: KSC-390C-2949.02
Dup. Neg. No.: L92-18257
LISAR NO.: EL-1994-00634
Photo Credit: KSC
Photo Date: 4/8/90
Location: SAEF II
Subject: Postflight Detail of Left Side of Bay A

***Figure 648 (Postflight).*** Tray A1 was adjacent to this part (right intercostal of bay A) of longeron B. The pattern fades near the center of the bay, but it gets darker near the right intercostal.

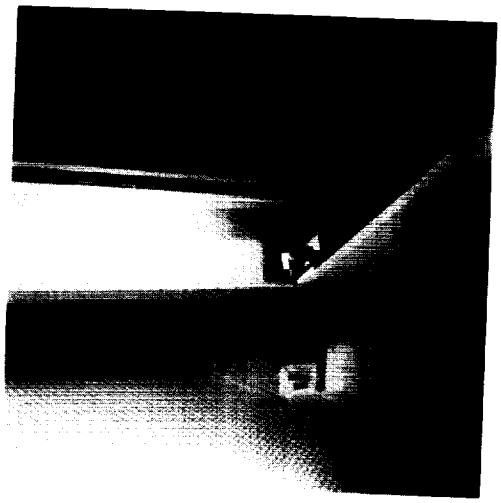

Figure 648
Photo No.: KSC-390C-2949.04
Dup. Neg. No.: L92-18259
LISAR NO.: EL-1994-00635
Photo Credit: KSC
Photo Date: 4/8/90
Location: SAEF II
Subject: Postflight Detail of Right Side of Bay A

***Figure 649 (Postflight).*** Tray B1 was adjacent to this part (left intercostal of bay B) of longeron B. There is a significant and well-defined pattern of discoloration with multiple shading near the left intercostal.

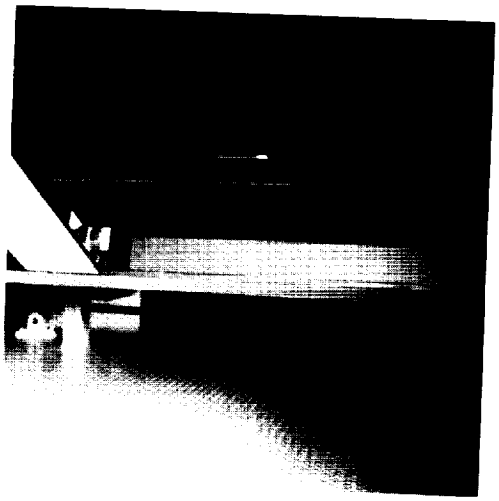

Figure 649
Photo No.: KSC-390C-2949.05
Dup. Neg. No.: L92-18260
LISAR NO.: EL-1994-00636
Photo Credit: KSC
Photo Date: 4/8/90
Location: SAEF II
Subject: Postflight Detail of Left Side of Bay B

***Figure 650 (Postflight).*** Tray B1 was adjacent to this part (right intercostal of bay B) of longeron B. There is a significant and well-defined pattern of discoloration with multiple shading near the right intercostal.

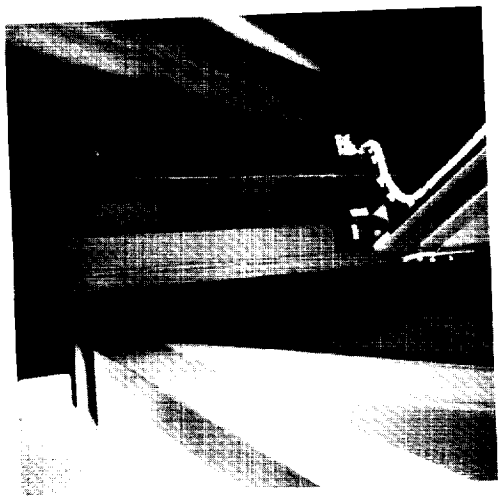

Figure 650
Photo No.: KSC-390C-2949.07
Dup. Neg. No.: L92-18262
LISAR NO.: EL-1994-00637
Photo Credit: KSC
Photo Date: 4/8/90
Location: SAEF II
Subject: Postflight Detail of Right Side of Bay B

No photograph exists of Bay C.

***Figure 651 (Postflight).*** Tray D1 was adjacent to this part (center ring of bay D) of longeron B. There is a small faint pattern of discoloration on the longeron near the center ring.

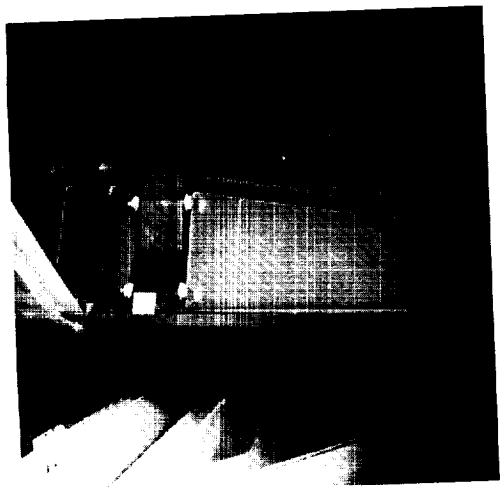

Figure 651
Photo No.: KSC-390C-2949.08
Dup. Neg. No.: L92-18263
LISAR NO.: EL-1994-00638
Photo Credit: KSC
Photo Date: 4/8/90
Location: SAEF II
Subject: Postflight Detail of Left Side of Bay D

***Figure 652 (Postflight).*** Tray D1 was adjacent to this part (right intercostal of bay D) of longeron B. There is a distinct pattern of discoloration near the right intercostal but none in the center.

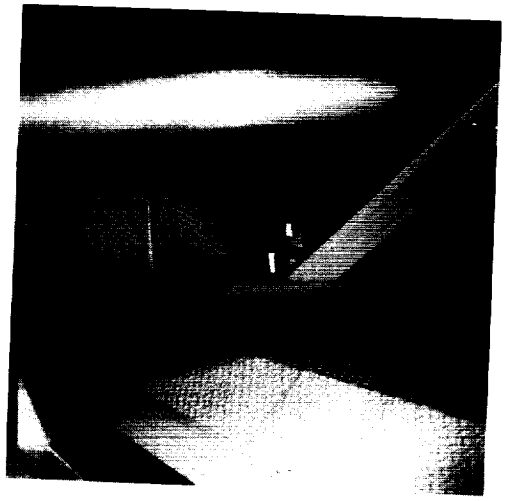

Figure 652
Photo No.: KSC-390C-2949.10
Dup. Neg. No.: L92-18265
LISAR NO.: EL-1994-00639
Photo Credit: KSC
Photo Date: 4/8/90
Location: SAEF II
Subject: Postflight Detail of Right Side of Bay D

***Figure 653 (Postflight).*** Tray E1 was adjacent to this part (left intercostal of bay E) of longeron B. There is a significant and well defined pattern of discoloration with multiple shadings near the left intercostal.

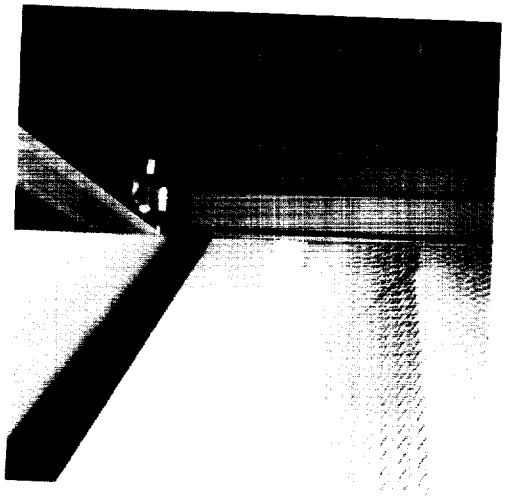

Figure 653
Photo No.: KSC-390C-2949.11
Dup. Neg. No.: L92-18266
LISAR NO.: EL-1994-00640
Photo Credit: KSC
Photo Date: 4/8/90
Location: SAEF II
Subject: Postflight Detail of Left Side of Bay E

***Figure 654 (Postflight).*** Tray E1 was adjacent to this part (right intercostal of bay E) of longeron B. There is a significant and well defined pattern of discoloration with multiple shadings near the right intercostal.

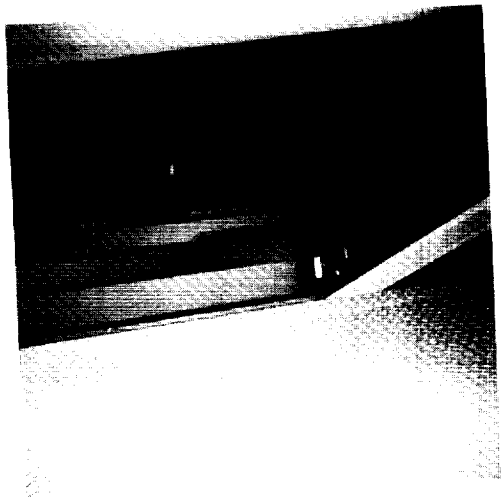

Figure 654
Photo No.: KSC-390C-2950.02
Dup. Neg. No.: L92-20470
LISAR NO.: EL-1994-00641
Photo Credit: KSC
Photo Date: 4/8/90
Location: SAEF II
Subject: Postflight Detail of Right Side of Bay E

***Figure 655 (Postflight).*** Tray F1 was adjacent to this part (left intercostal of bay F) of longeron B. There is a significant and well defined pattern of discoloration with multiple shadings near the left intercostal.

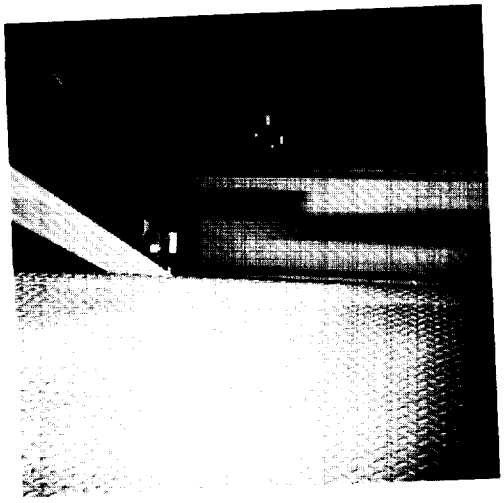

Figure 655
Photo No.: KSC-390C-2950.03
Dup. Neg. No.: L92-20471
LISAR NO.: EL-1994-00606
Photo Credit: KSC
Photo Date: 4/8/90
Location: SAEF II
Subject: Postflight Detail of Left Side of Bay F

***Figure 656 (Postflight).*** Tray F1 was adjacent to this (right intercostal of bay F) part of longeron B. There is a significant and well defined pattern of discoloration with multiple shadings near the right intercostal.

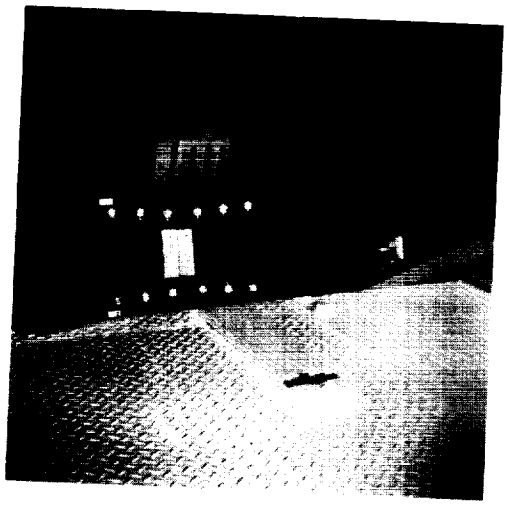

Figure 656
Photo No.: KSC-390C-2950.05
Dup. Neg. No.: L92-20473
LISAR NO.: EL-1994-00607
Photo Credit: KSC
Photo Date: 4/8/90
Location: SAEF II
Subject: Postflight Detail of Right Side of Bay F

***Figure 657 (Postflight).*** Tray A6 was adjacent to this part (right intercostal of bay A) of longeron F. The Earth-facing end of LDEF is to the right in this photograph, which shows longeron F between rows 5 and 6. There is a significant and well-defined pattern of discoloration near the right intercostal. Note the sharp patterns of the bolts and wiring clamp.

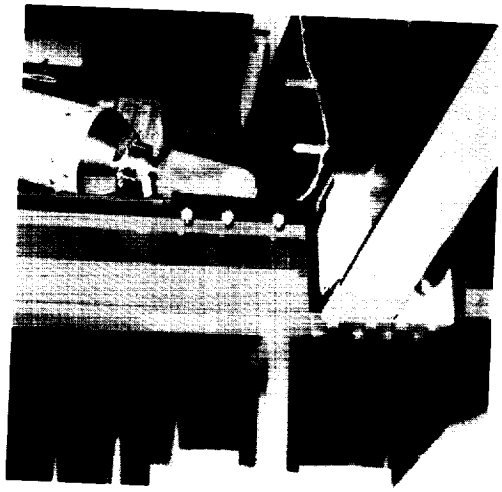

Figure 657
Photo No.: KSC-390C-3459.05
Dup. Neg. No.: L92-19138
LISAR NO.: EL-1994-00548
Photo Credit: KSC
Photo Date: 4/20/90
Location: SAEF II
Subject: Postflight Detail of Right Side of Bay A

***Figure 658 (Postflight).*** Tray A6 was adjacent to this part (left intercostal of bay A) of longeron F. There is a significant and well defined pattern of discoloration near the left intercostal. Note the wiring clamp patterns.

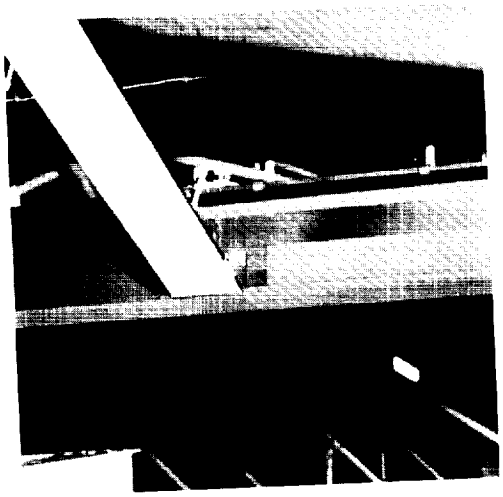

Figure 658
Photo No.: KSC-390C-3459.07
Dup. Neg. No.: L92-19140
LISAR NO.: EL-1994-00549
Photo Credit: KSC
Photo Date: 4/20/90
Location: SAEF II
Subject: Postflight Detail of Left Side of Bay A

***Figure 659 (Postflight).*** Tray B6 was adjacent to this part (right intercostal of bay B) of longeron F. There is a significant and well-defined pattern of discoloration near the right intercostal. Note the wiring clamp and wiring wrap patterns. The patterns fade near the center of the bay.

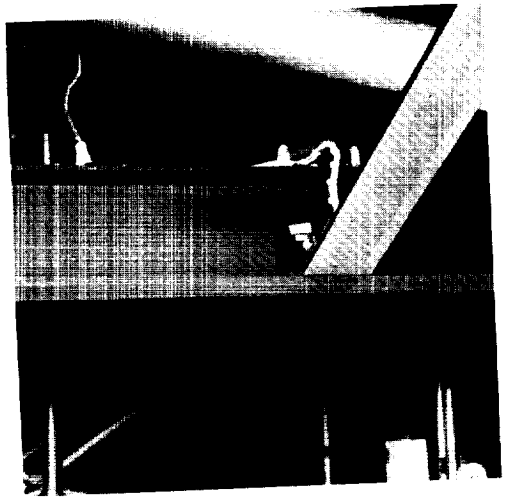

Figure 659
Photo No.: KSC-390C-3459.08
Dup. Neg. No.: L92-19141
LISAR NO.: EL-1994-00550
Photo Credit: KSC
Photo Date: 4/20/90
Location: Subject: SAEF II
Subject: Postflight Detail of Right Side of Bay B

***Figure 660 (Postflight).*** Tray B6 was adjacent to this part (left intercostal of bay B) of longeron F. There is a significant and well-defined pattern of discoloration near the left intercostal. Note the faint pattern of the wiring clamp. The pattern fades near the center of the bay.

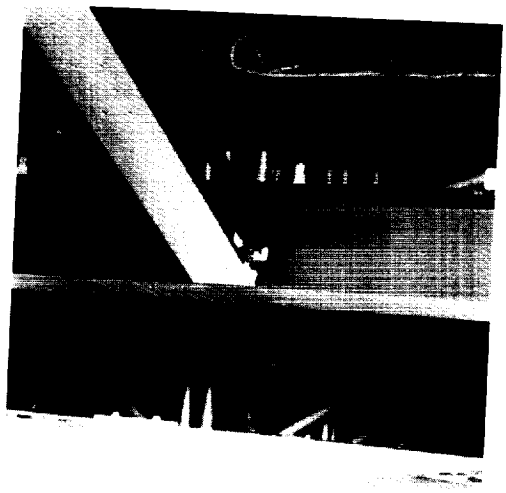

Figure 660
Photo No.: KSC-390C-3459.10
Dup. Neg. No.: L92-19143
LISAR NO.: EL-1994-00551
Photo Credit: KSC
Photo Date: 4/20/90
Location: SAEF II
Subject: Postflight Detail of Left Side of Bay B

***Figure 661 (Postflight).*** Tray C6 was adjacent to this part (right intercostal of bay C) of longeron F. There is a significant and well-defined pattern of discoloration with distinctly different shadings near the right intercostal. Note the sharp cutoff of the discoloration just to the left of the intercostal.

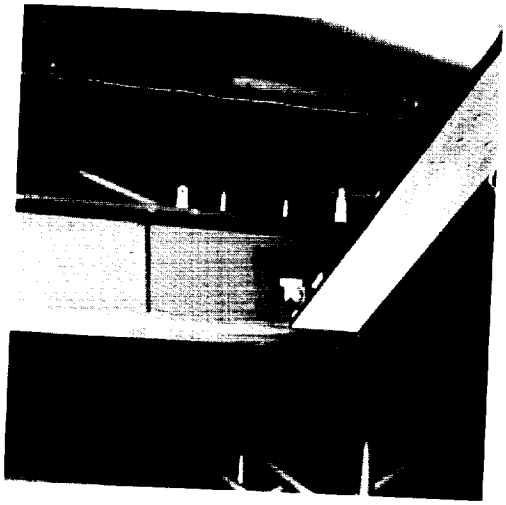

Figure 661
Photo No.: KSC-390C-3459.11
Dup. Neg. No.: L92-19144
LISAR NO.: EL-1994-00552
Photo Credit: KSC
Photo Date: 4/20/90
Location: SAEF II
Subject: Postflight Detail of Right Side of Bay C

***Figure 662 (Postflight).*** Tray C6 was adjacent to this part (center ring of bay C) of longeron F. There is a faint indication of a pattern of discoloration near the center ring.

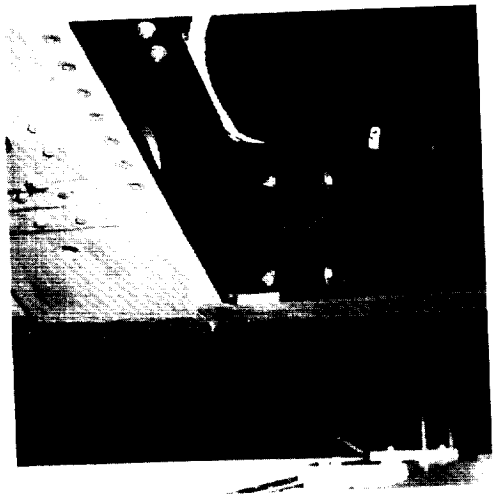

Figure 662
Photo No.: KSC-390C-3460.02
Dup. Neg. No.: L92-20027
LISAR NO.: EL-1994-00553
Photo Credit: KSC
Photo Date: 4/20/90
Location: SAEF II
Subject: Postflight Detail of Left Side of Bay C

***Figure 663 (Postflight).*** Tray D6 was adjacent to this (center ring of bay D) part of longeron F. There is a small pattern of discoloration near the center ring.

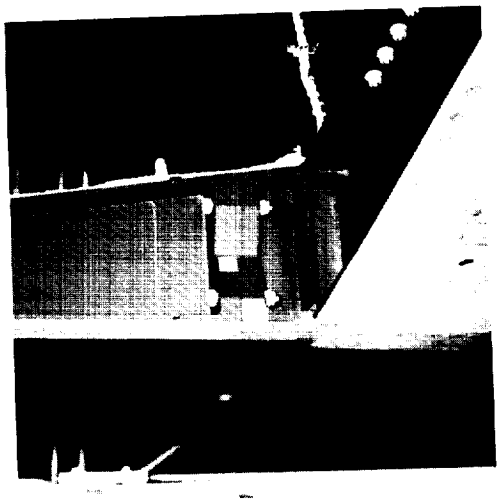

Figure 663
Photo No.: KSC-390C-3460.03
Dup. Neg. No.: L92-20028
LISAR NO.: EL-1994-00554
Photo Credit: KSC
Photo Date: 4/20/90
Location: SAEF II
Subject: Postflight Detail of Right Side of Bay D

***Figure 664 (Postflight).*** Tray D6 was adjacent to this part (left intercostal of bay D) of longeron F. There is a significant and well-defined pattern of discoloration near the left intercostal. Note the faint wire clamp pattern. The pattern fades near the center of the bay.

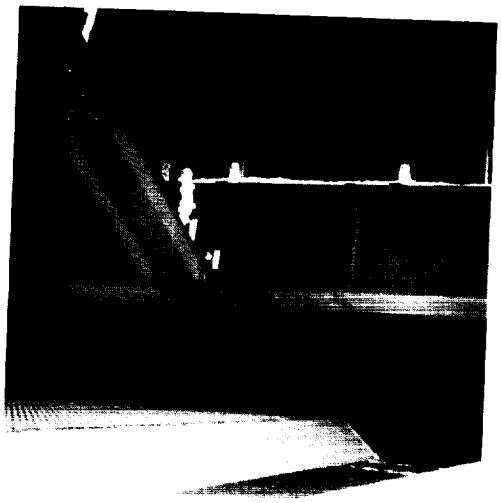

Figure 664
Photo No.: KSC-390C-3460.05
Dup. Neg. No.: L92-20030
LISAR NO.: EL-1994-00555
Photo Credit: KSC
Photo Date: 4/20/90
Location: SAEF II
Subject: Postflight Detail of Left Side of Bay D

***Figure 665 (Postflight).*** Tray E6 was adjacent to this part (right intercostal of bay E) of longeron F. There is a distinct and well-defined pattern of discoloration. Note the wire clamp patterns.

Figure 665
Photo No.: KSC-390C-3460.06
Dup. Neg. No.: L92-20031
LISAR NO.: EL-1994-00556
Photo Credit: KSC
Photo Date: 4/20/90
Location: SAEF II
Subject: Postflight Detail of Right Side of Bay E

***Figure 666 (Postflight).*** Tray E6 was adjacent to this part (left intercostal of bay E) of longeron F. There is a significant and well-defined pattern of discoloration.

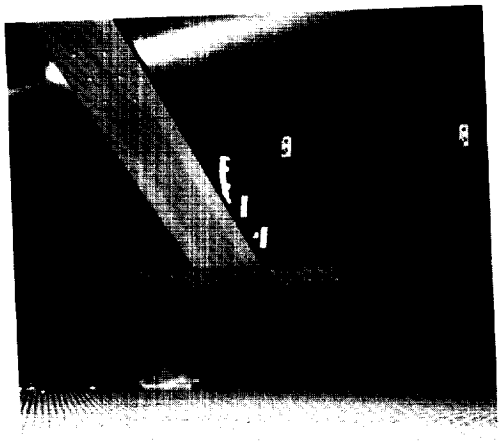

Figure 666
Photo No.: KSC-390C-3460.08
Dup. Neg. No.: L92-20033
LISAR NO.: EL-1994-00578
Photo Credit: KSC
Photo Date: 4/20/90
Location: SAEF II
Subject: Postflight Detail of Left Side of Bay E

***Figure 667 (Postflight).*** Tray F6 was adjacent to this part (right intercostal of bay F) of longeron F. There is a faint pattern of discoloration near the right intercostal. There is also a sharp cutoff of the discoloration just to the left of the intercostal.

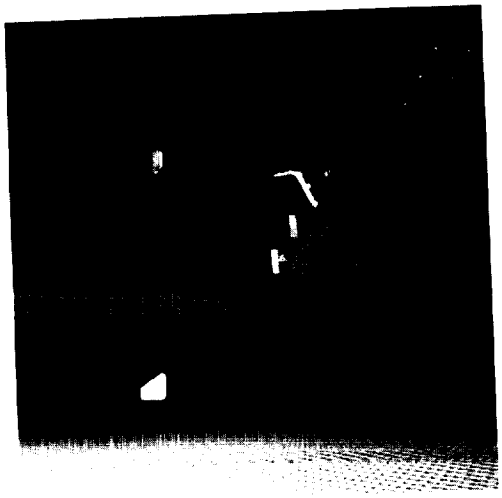

Figure 667
Photo No.: KSC-390C-3460.09
Dup. Neg. No.: L92-20034
LISAR NO.: EL-1994-00579
Photo Credit: KSC
Photo Date: 4/20/90
Location: SAEF II
Subject: Postflight Detail of Right Side of Bay F

***Figure 668 (Postflight).*** Tray F6 was adjacent to this part (left intercostal of bay F) of longeron F. There is a small but distinct pattern of discoloration near the left intercostal.

Figure 668
Photo No.: KSC-390C-3460.11
Dup. Neg. No.: L92-20036
LISAR NO.: EL-1994-00580
Photo Credit: KSC
Photo Date: 4/20/90
Location: SAEF II
Subject: Postflight Detail of Left Side of Bay F

# Photographs of Selected Areas of Discoloration

***Figure 669 (Postflight).*** Note the extensive contamination and discoloration. There is the pattern of a diagonal structural member across the back of the tray. There is also a pattern where a wiring harness has been removed from the lower left tray members.

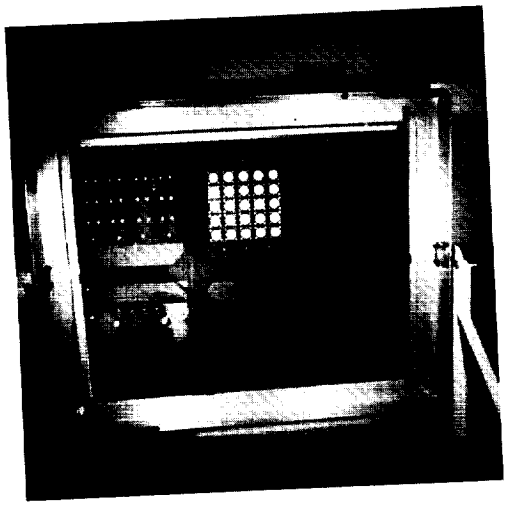

Figure 669
Photo No.: KSC-390C-1545.08
Dup. Neg. No.: L91-9080
LISAR NO.: EL-1994-00710
Photo Credit: KSC
Photo Date: 3/2/90
Location: KSC
Subject: Postflight View of Back of Tray C3

***Figure 670 (Postflight).*** The interior of the LDEF was essentially black to provide radiative coupling in thermal control of the facility. Note the pattern of discoloration on the back of tray B2 in the top left of the photograph.

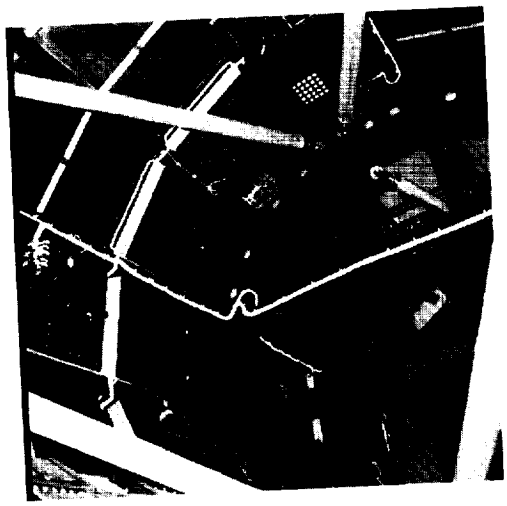

Figure 670
Photo No.: KSC-390C-1481.07
Dup. Neg. No.:L91-15630
LISAR NO.: EL-1994-00049
Photo Credit: KSC
Photo Date: 2/28/90
Location: SAEF II
Subject: Postflight View of LDEF Interior

***Figure 671 (Postflight).*** This photograph of tray F11 shows extensive discoloration and contamination. Note the discoloration below the rivet heads. It appears that during tray manufacture or integration, tape had been placed on the tray sidewall and the tray was improperly cleaned after the tape was removed.

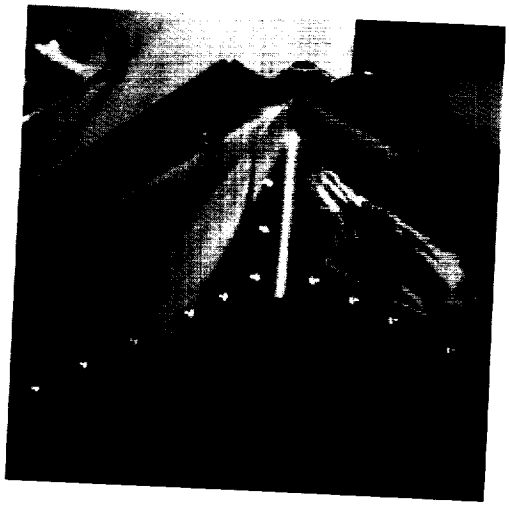

Figure 671
Photo No.: KSC-390C-1537.12
Dup. Neg. No.: L91-11508
LISAR No.: LISAR No.: EL-1994-00691
Photo Credit: KSC
Photo Date: 3/2/90
Location: SAEF II
Subject: Postflight Detail of Tray F11 Discoloration

***Figure 672 (Postflight).*** This photograph of the interior flange of the longeron D shows the discoloration pattern after the wiring harness and wire holding clips were removed.

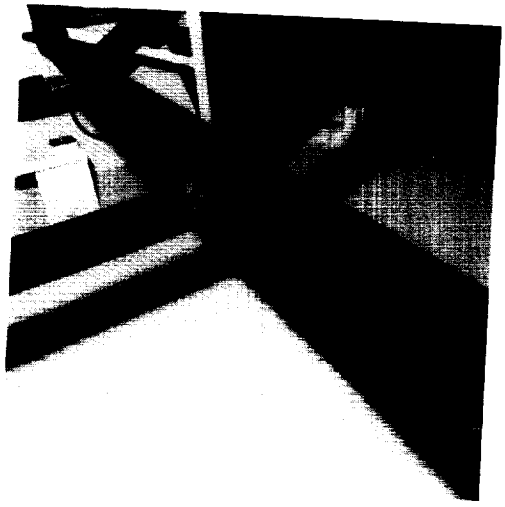

Figure 672
Photo No.: KSC-390C-3622.10
Dup. Neg. No.: L92-20238
LISAR NO.: EL-1994-00586
Photo Credit: KSC
Photo Date: 4/30/90
Location: SAEF II
Subject: Postflight Detail of Wiring Harness Pattern on Longeron D

***Figure 673 (Postflight).*** This photograph is of the structural member adjacent to the end of longeron F (between rows 5 and 6) at the Earth-facing end of the LDEF. Note the extensive color and highly directional patterns of the bolts and nuts.

Figure 673
Photo No.: L90-01517
LISAR NO.: EL-1994-00054
Photo Credit: LaRC
Photo Date: 1990
Location: SAEF II
Subject: Postflight Detail of Structure Discoloration

***Figure 674 (Preflight).*** This photograph is of trunnion scuff plates (4 flight plates and 2 spares) prior to flight. Note the bright color.

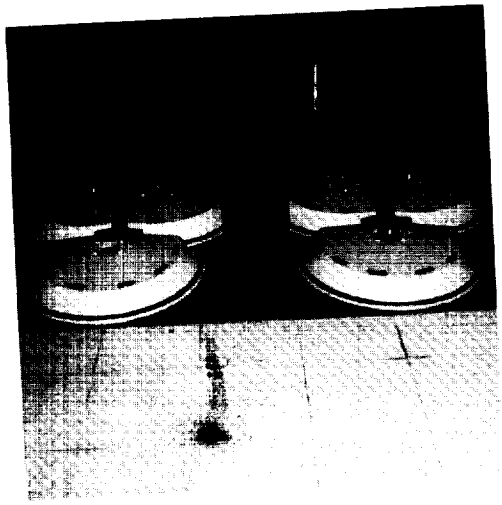

Figure 674
Photo No.: L83-09232
LISAR NO.: EL-1994-00703
Photo Credit: LaRC
Photo Date: 1983
Location: LaRC
Subject: Preflight Detail of Scuff Plates

***Figure 675 (Postflight).*** This set of trunnion scuff plates was removed from the LDEF after flight. The brighter scuff plate was on the leading side during flight, while the duller one was on the trailing side.

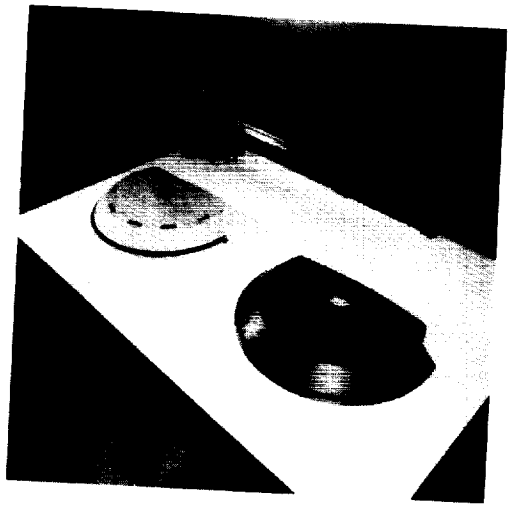

Figure 675
Photo No.: L90-01537
LISAR NO.: EL-1994-00055
Photo Credit: LaRC
Photo Date: 1990
Location: SAEF II
Subject: Postflight Detail of Scuff Plates

# References


1. Clark, L. G.; Kinard, W. H.; Carter, D. L., Jr.; and Jones, J. L., Jr., eds.: *Long Duration Exposure Facility (LDEF)—Mission 1 Experiments*. NASA SP-473, 1984.

2. Berrios, William M.: Use of the Long Duration Exposure Facility's Thermal Measurement System for the Verification of Thermal Models. *LDEF: 69 Months in Space—First Post-Retrieval Symposium*, Part 1, Arlene S. Levine, ed., NASA CP-3134, 1992, pp. 69–83.

3. Sampair, Thomas R.; and Berrios, William M.: Effects of Low Earth Orbit Environment on the Long Duration Exposure Facility Thermal Control Coatings. *LDEF: 69 Months in Space—First Post-Retrieval Symposium*, Part 2, Arlene S. Levine, ed., NASA CP-3134, 1992, pp. 935–944.

4. Sampair, Thomas R.: A Generalized Approach to the Thermal Analysis of the Long Duration Exposure Facility's Flight Experiments. *LDEF: 69 Months in Space—Second Post-Retrieval Symposium*, Part 1, Arlene S. Levine, ed., NASA CP-3194, 1993, pp. 27–50.

5. Berrios, William M.; and Sampair, Thomas R.: *Long Duration Exposure Facility Post-Flight Thermal Analysis*, Part 1, NASA TM-104208, 1992.

6. Davis, L. K.; Sanders, W. W.; Hagan, G. R.; and Andrus, A. M. Greg: *Gravity Gradient Test Satellite*. Document No. 67SD4418, Contract AF 04(695)734, General Electric, Sept. 1968.

7. Das, Aniruddha; Foulke, Howard F.; and Siegel, Sherman H.: *Passive Stabilization of the Long Duration Exposure Facility (LDEF)*. NASA CR-132556, 1974.

8. Siegel, S. H.; and Vishwanath, N. S.: *Analysis of the Passive Stabilization of the Long Duration Exposure Facility (LDEF)*. NASA CR-159023, 1977.

9. Kinard, William H.; and Martin, Glenna D.: Long Duration Exposure Facility (LDEF) Space Environments Overview. *LDEF—69 Months in Space: First Post Retrieval Symposium*, Arlene S. Levine, ed., NASA CP-3134, Part 1, June 1991, pp. 49–60.