NASA Conference Publication 2324

1984 Get Away Special Experimenter's Symposium

Proceedings of a symposium held at
NASA Goddard Space Flight Center
Greenbelt, Maryland
August 1-2, 1984

NASA

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Clarke R. Prouty, *Editor*
NASA Goddard Space Flight Center

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National Aeronautics
and Space Administration

**Scientific and Technical
Information Branch**

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1984 GAS EXPERIMENTER SYMPOSIUM AGENDA

WEDNESDAY, AUGUST 1

8:00 a.m.	Pre-registration
9:00 a.m.	Opening Remarks - Mr. Clarke Prouty, GSFC
9:05 a.m.	Introduction - Mr. Leonard Arnowitz, GSFC
9:15 a.m.	Welcome - Dr. Noel Hinners, Director, GSFC
9:30 a.m.	STS Overview - Mr. Jesse Moore, NASA Headquarters
10:00 a.m.	Session I: Chairman: Mr. Clarke Prouty, GSFC

Presentations:

Get Away Special - Program Evolution From 1976-1984
- R. Gilbert Moore

Penn State Get Away Special
- M. Thames, D. Moul, Penn State
- R. Birman, General Electric Space Division

Results of the Purdue University GAS-I Payload
- R. Perez, Purdue University

Some Results of the USU Involvement in the GAS Program
- R. Megill, Utah State University

ARC Discharge Convection Studies: A Space Shuttle Experiment
- A. Bellows and A. Feuersanger, GTE Laboratories

Spacescapes/Payloads for the Arts
- J. Davis, Massachusetts Institute of Technology

1:30 p.m. Session II: Chairman: Mr. Clarke Prouty, GSFC

Presentations:

Crystal Growth of Artificial Snow
- S. Kimura, A. Oka, M. Taki, Asahi Shimbun Co.
- R. Kuwano, H. Ono, R. Nagura, Y. Narimatsu, J. Tanii, Y. Kamimiyata, NEC Corp.

Overview - Get Away Special Competition
- C. Trump, SPAR Aerospace Ltd.

Modular and Standardized GAS Payload Hardware
- G. Schmitt, Kayser-Threde GmbH

El Paso and Ysleta Schools Get Away Special Payload #34
- S. Azar

Session II, continued

GAS 007 Marshall Amateur Radio Club Experiment (MARCE)
- E. Stluka, Marshall Space Flight Center

An Investigation of Single Cell Plant and Animal Growth in Micro-Gravity as the Basis of a Food Source for Extended Space Missions
- M. Schniederman, Wester' Shore Research & Development Centre

Gypsy Moths and American Dog Ticks: Space Partners
- D. Hayes, N. Morgan, R. Webb, U.S. Department of Agriculture

Nuclear Particle Detection Using a Track-Recording Solid
- M. Weber, D. Weber, Purdue University

Experiment Hardware Design for Examination of Liquids in a Surface Tension Tank
- P. Vits, ERNO Raumfahrttechnik GmbH

4:30 p.m.	Adjourn
6:00 p.m.	Social Hour at GSFC Recreation Center
7:00 p.m.	Dinner - Purchase Tickets at Registration
8:00 p.m.	After Dinner Speaker

THURSDAY, AUGUST 2

8:00 a.m. Announcements, Opening Remarks, Mr. Clarke Prouty

8:15 a.m. Session III: Chairman: Mr. Clarke Prouty, GSFC

Presentations:

Design and Development of Shuttle Get Away Special Experiment G-0074
- G. Orton, McDonnell Douglas Astronautics Company

An Investigation of the Phototropic Effect on Seedling Orientation in a Microgravity Environment: A Student Involvement Project
- J. Barainca, Brighton High School

Laboratory Discharge Studies of a 6 V Alkaline Lantern-Type Battery Eveready Energizer No. 528, Under Various Ambient Temperatures (-15°C and +22°C) and Loads (30 and 60)
- S. Ahrens, N.C. A&T State University

Project Explorer: Get Away Special #007
- A. Henderson, Jr., Alabama Space & Rocket Center

Thermocapillary Flow and Phase Change in Microgravity; Results from GAS Payload G-004
- S. Thomas, Utah State University

G-38, 39, & 40 - An Artist's Exploration of Space
- J. McShane, Marshall-McShane

A Versatile Structure for GAS Payloads
- K. Punwani, N.C. A&T State University

The G-002 JUFO-1 Payload, Its Objectives and Results
- G. Schmitt, Kayser-Threde GmbH

The Development of a Project Plan for the Get Away Special (GAS) Program
- S. Butow, Aero-Auto Ind.

GAS-286 Ultralight Reactive Metal Foams Produced as Structural Shapes in Space: System Design
- F. Cocks, J. Morrill, M. Feldman, Duke University

An Extreme Ultraviolet Spectrometer Experiment for the Shuttle Get Away Special Program
- R. Conway, R. McCoy, R. Meier, G. Mount, D. Prinz, J. Young, G. Carruthers, Naval Research Laboratory

Session IV: Chairman: Mr. James Barrowman, GSFC

1:30 p.m.	GAS Payload Processing at GSFC - J. Barrowman, GSFC
2:00 p.m.	NASA Technical Panel Presentations
3:00 p.m.	NASA Technical Panel Questions and Answers
4:30 p.m.	End of Symposium

PENN STATE GET AWAY SPECIAL

G-62

Mike Thames Penn State
Dave Moul Penn State
Bob Birman General Electric Space Division

June 1, 1984

INTRODUCTION

The Get Away Special program at Penn State has become a major factor in the education of a large number of engineering students. The Penn State GAS program started in the winter of 1981 with the donation of a 2.5 cubic foot canister by the General Electric Space Division, which is located in Valley Forge, Pa. With the full support of the Space Division's Vice President Al Rosenberg and the Military Payloads Division Manager Bill Phucas, the Penn State GAS program was able to utilize the GE satellite testing facilities to insure the payload's success. Bob Birman, the GE program Manager, has been instrumental in obtaining exotic space rated materials and much needed technical advice. Although Mr. Birman's job is in the Military Division, his expertise with the Space Division and its' personnel has been crucial.

In addition to some monetary funding, GE has donated the services of its' thermal vacuum and vibration testing personnel and facilities. Full scale testing was accomplished in November of 1983 during a period of two weeks. The tests represented state of the art spacecraft testing available to only major aerospace corporations. The testing is believed to have surpassed all previous GAS program testing, including that done by NASA.

The canister was donated to Penn State's College of Engineering through the assistance of Dean Wilbur Meier. The Administrative duties at Penn State are being handled by the Associate Dean of Research, Dr. Edward Klevans. Dean Klevans, in addition to the GAS program, handles many high tech research programs at Penn State, and is adept at cutting through bureaucratic red tape. An open call for experiments was made by Dean Klevans to the undergraduate engineering students in December of 1981. The tentative ideas were presented and a feasability analysis of each idea was conducted by the students themselves. The three experiments chosen were selected by the junior students and their faculty advisors. The experiments investigate critical problems whose solution requires a micro-G environment. Groups of students volunteered to work on the experiments on their own time, and a few turned their work into undergraduate theses. Initially this was to be a one-year project with few credit-hours and little funding offered. Two and a half years and twelve thousand dollars later, the full scope of such an undertaking has been realized.

The major funding for this project has come from the Penn State Engineering Society which is composed of the PSU engineering alumni. The alumni have been very understanding about the monetary needs of a program of this scope. Minor funds were solicited from some of the engineering departments and their professional societies. The project was housed in a small room in the basement of an old engineering building, acquired with the help Bob Houtz of the College of Engineering.

EXPERIMENT DESCRIPTIONS

The three experiments to be flown are unique in that they address problems currently under parallel investigation by major corporations. The experiments have been designed, constructed and tested by the students without professional aid. The Convection experiment was designed and fabricated by one student, Mark Kedzierski. This experiment will isolate the effect of convection in heat transfer. There are three modes of heat transfer: radiation, conduction, and convection. These three modes are inherently linked in the one-G environment of Earth and it is empirically difficult to separate their individual effects. The convective effects may be determined by comparing the results of this experiment performed in space and on Earth.

The experiment consists of three concentric cylinders. The inner cylinder contains a resistive heat source that will heat oil between the inner and middle cylinders. There will exist a partial vacuum between the middle and outer cylinders. The temperature measurements will be spatially recorded by 16 high sensitivity thermobeads. Heat transfer will be measured, and after comparison to one-G results, the effect of convection in heat transfer will be determined.

The Terminal Velocity experiment headed by Jeff Rice and Brett Kline will determine the effect that a micro-gravity environment will have on a liquid´s surface tension. One method of finding a liquid´s surface tension is to measure its´ terminal velocity, which is the highest speed a liquid particle can strike a hard surface without breaking apart. Surface tension is directly proportional to the liquid´s terminal velocity.

This experiment will determine the terminal velocity and hence the surface tension of two liquids in space by injecting droplets into the path of a moving piston, which will strike the droplets and send them to a special retaining foam donated by Scott Foam, Chester, Pa. This procedure will be repeated in its´ sealed pressure vessel with the piston moving slightly faster each time, until the droplets begin to break up upon impact (i.e. when the terminal velocity has been reached). The impacts will be recorded photographically by a 35mm Nikon camera. This will yield the piston´s speed at time of impact. By comparing the results with the results from a one-G simulation, with all other factors constant, the effect of gravity on surface tension may be determined and hence help quantify surface tension formulae.

The remaining experiment investigates the problem of liquid slosh in spin stabilized satellites. Group leader Joe Bieber and his team of Aerospace engineers hope to measure the slosh forces and observe photographically the slosh motion resulting from a perturbation in a model satellite propellant tank. Propellant slosh in spacecraft dissipates energy, thus resulting in spacecraft nutation. Nutation is a wobbling motion about the spacecraft´s spin axis. This, if left uncorrected, can render a spinning satellite useless. For example, a spinning satellite used for a communication relay requires very precise pointing accuracy, and liquid slosh can hinder this. The prototype system for this experiment is the COMSAT INTELSAT IV communication satellite. COMSAT has experienced and investigated this problem but it still remains unresolved. Hughes Aerospace and Ford Aerospace have expressed interest in the results.

The liquid slosh experiment will simulate the INTELSAT IV satellite undergoing an attitude maneuver. Two conispherical tanks, manufactured from clear acrylic and filled with an aqueous solution, will be mounted on a spin table rotating at about 180 rpm (a spin rate which will provide dynamic similitude between the model and prototype systems). The table will then be impulsively tilted and the resulting slosh motion will analyzed and recorded. Two modified World War II vintage 16mm gun cameras will visually record the slosh motion at a rate of 16 frames/sec. The lighting will be provided by an array of LED´s, which will necessitate the use of KODAK´s extended red sensitivity Tech-pan 2415 film. This film, which was selected and donated by Bob Anwyl of KODAK´s scientific and technical department, has an ESTAR polyester base to survive vacuum exposure and will be an unique test in itself of photography in space.

High resolution piezoelectric force transducers being used to measure the resulting slosh forces (and yet withstand a high-G launch), were acquired through the invaluable assistance of Paul Bussman of Kistler Instrument Corp. of Amherst NY. The simulation will be repeated for three different fill ratios at three different spin rates. This will provide a photographic record of the acutal slosh motion and an analog record of the associated forces for nine attitude conditions. This experiment will do much to help assess and quantify a very important problem in spacecraft dynamics.

ELECTRONICS

The electronics involved in the operation of these experiments are the concern of Steve Herr and his team of Electrical engineers. They have developed the power, sequencing and data recording systems for the three experiments. These systems will have to withstand a high-G launch, vacuum, temperature variations and incident radiation.

The electrical power will be supplied by an array of Gates Lead-Acid cells. These cells were chosen due to their consistent safety characteristics in space, a prime concern of NASA. NASA has imposed a three month waiting period prior to launch, which seriously affects the power capacity at launch . Due to these and other factors, low power CMOS circuitry was used throughout the design. Many state-of-the-art CMOS components were donated by INTEL, National SemiConductor, and Harris Corp.

Because the astronauts' control of the experiments is limited to three on-off switches, the experiments must be internally controlled and sequenced. This will be accomplished by the recently developed NSC800 low power microprocessor, which requires the newly released 74HC CMOS support chips. This entire system will be unique in that it has the low power characteristics of CMOS and the high speed characteristics of 74LS Schottky. Using these chips, the power dissipation for the entire mother board averages only 200 milliwatts. This eliminates the need for extensive heat-sinking. This system also has the advantage of having an access time of 200 nanoseconds, rather than the 450 nanoseconds common to standard CMOS. It is believed that these characteristics will increase the reliability and survivability of the electronics package.

The data storage will be accomplished through the use of an INTEL 1 MEG magnetic bubble memory. This device will record the data physically rather than electrically; this is necessary due to the inevitable battery discharge. Harris Semiconductor Corp. has donated 256K CMOS RAM for the scratchpad memory that will be loaded into the bubble. The data storage for the convection experiment will use two EEPROMs recently developed and donated by INTEL. These are exceptional in that they only need 5 volts to write into PROM. This data is then permanently stored until purged.

The electronics have to survive extreme environmental conditions, which has mandated the use of high technology components. It is believed that the system designed is far superior to any flown in previous GAS payloads. This will be a unique test of whether undergraduate engineers can assemble a state-of-the-art microprocessor and bubble memory recorder that outperforms the best 'ready-made' systems available today. This attempt would not have been possible without the donation of prototype components that are not on the market as of yet. Thanks to many individual and corporate contributions, this GAS project is utilizing the cutting edge of technology.

TESTING

The extensive testing of this payload would not have been possible without the donation of a test canister by the PSU College of Engineering. This canister was built to NASA specifications and was vibration tested, along with the student built support structure, at HRB Singer in State College. The fundamental resonant frequency of the canister with a simulated payload was determined. This was done to insure the simulation canister's survival through actual testing and to recognize the canister's contribution to the payload's fundamental frequency. The individual experiment components were vibration tested at the PSU Mechanical Engineering Dynamic Structures lab. The payload construction materials were mechanically tested to insure their structural margins of safety. Various epoxies and fasteners were also mechanically tested to determine their suitability in payload construction and environment.

When the actual payload was finished, full scale testing was scheduled at GE when their facilities were not in use. Three axis vibration testing was completed to NASA specifications. Full spacecraft vibration testing was found to be more complicated than implied in NASA literature. The initial testing procedure was designed wholly by the students, but during actual testing it was found that, through lack of experience and information, the procedure was in need of modification. This was accomplished through consultation with GE's helpful technicians. The testing period was originally scheduled for two days, in reality it took a week. An important lesson was learned about the realities of scheduling.

The thermal-vacuum testing followed the vibration testing and was originally scheduled for three days. However, it also took a week. The test canister was equipped with a student-sewn thermal blanket made to NASA specifications. It was composed of five layers of dacron felt, two layers of aluminized mylar spaced with nylon netting and a covering of beta-cloth. In addition to the blanket, a thermal shroud was student fabricated to simulate deep space conditions. This was an aluminum canister that uniformly surrounded the simulation canister; resistive heating pads on the outer canister radiated heat to simulate the hot case environment (+90 C). The cold case (-60 C) was achieved through the circulation of liquid nitrogen through the vacuum chamber. The test canister and payload were cycled through hot and cold worst -case temperature extremes in a vacuum of 10(-6) torr. The cycles simulated orbiter hot and cold cycles as documented by the Flight Verification Payload (FVP) flown on STS-3. Internal payload components were operated during the hot cycles to insure worst case heat dissipation effects. At no time during the testing did the internal payload temperature exceed +30 C or drop below + 15 C. It is hoped that the NASA built insulation will perform as well as the student built insulation.

One of the more interesting setbacks in the PSU GAS program occurred several weeks before a scheduled delivery date for the payload at the Cape. The Gates batteries installed in the payload were found to be of a different size than those tested by NASA. It had previously been assumed that all Gate´s cells were flight qualified on the basis of tests conducted by NASA for the Utah State payload. The PSU canister utilized a larger version of the same batteries, but this specific size had not been flight qualified. NASA then required either replacement of the cells with approved sized cells, or flight qualification testing by Penn State. Penn State opted to test the batteries themselves, rather than settle for a smaller capacity power supply. Another purpose of the test was to prove the cells could be safely sealed witin the battery box. GE ,on short notice, supplied a 1960´s vintage gas chromatograph out of their salvage warehouse. This unit had to be recalibrated and rejuvenated by the students due to its long period of disuse. The Aerospace engineers working on the project then had to effectively become chemical engineers to properly operate and evaluate the chromatograph. The batteries completed tests under various conditions of loading, shorting and standing; the gasses generated had to analyzed quantitatively and qualitatively. It was found that a minimal amount of hydrogen was generated under the worst case shorting conditions. Despite this, the battery expert at Goddard recommended that all battery boxes be vented into the cargo bay. This resulted in a last minute structural redesign to accomodate the plumbing and filters and also the dropping of a fourth PSU experiment that had originally been planned. It was learned here that the individual experimenters must conduct their own safety analysis and not rely upon outside sources to find all existing hazards.

CONCLUSION

The Get Away Special program is important in that it provides actual engineering experience. General Electric´s donation of the canister to Penn State has done much for the education of the many engineering students who worked to place the experiments in orbit. Without GE´s support in many uncountable areas, this project could not have achieved the level of confidence it now holds. It is obvious to PSU GAS members that to properly complete any type of GAS project an aerospace sponsor is necessary to fully understand the various problems encountered in space. The technical level of this payload far exceeded Penn State´s and GE´s initial estimations. Many of the problems encountered could only be solved by the experts at GE´s Space Division, who were often surprised at the level of the questions. The technical level was only made possible by the sponsorship of an outstanding aerospace corporation, like GE.

Results of the Purdue University GAS-I Payload

by

Rigoberto Perez

Abstract

This paper summarizes the results of Purdue University GAS-I payload and describes their implications from an engineering design standpoint. The payload consisted of one biological and two physical science experiments, along with the supporting subsystems. Some of these subsystems included, the structure, power supply, electronic controller and thermal control system. Data was obtained from one of the experiments, but electrical and mechanical malfunctions prevented the operation of the other two. The thermal control design maintained the desired temperatures and the structure successfully supported all components. The microprocessor collected and stored temperature readings and other data during the flight. A series of recommendations based on these results and our experiences are included in this report.

1. Introduction

The Purdue University GAS-I was housed inside a standard 2.5 cubic foot, 100 pound canister donated by an alumni in 1977. In 1978 experiment proposals were solicited by a faculty committee from the Purdue University community. Three experiments were selected for the project. The completed payload was flown on STS-7 in June, 1983.

The space science experiment is entitled "The Nuclear Particle Detection Experiment". The purpose of this experiment was the detection of nuclear particles that are encountered in the near earth space environment, and to study their subsequent paths after the particles penetrated a stack of sensitive sheets. The second experiment was a biological project entitled "The Seed Germination Experiment". A study of the effect of microgravity on the germination of sunflower seeds was the objective here. "The Fluid Dynamics Experiment" was intended to investigate the motion in low gravity conditions of a drop of mercury immersed in a clear liquid.

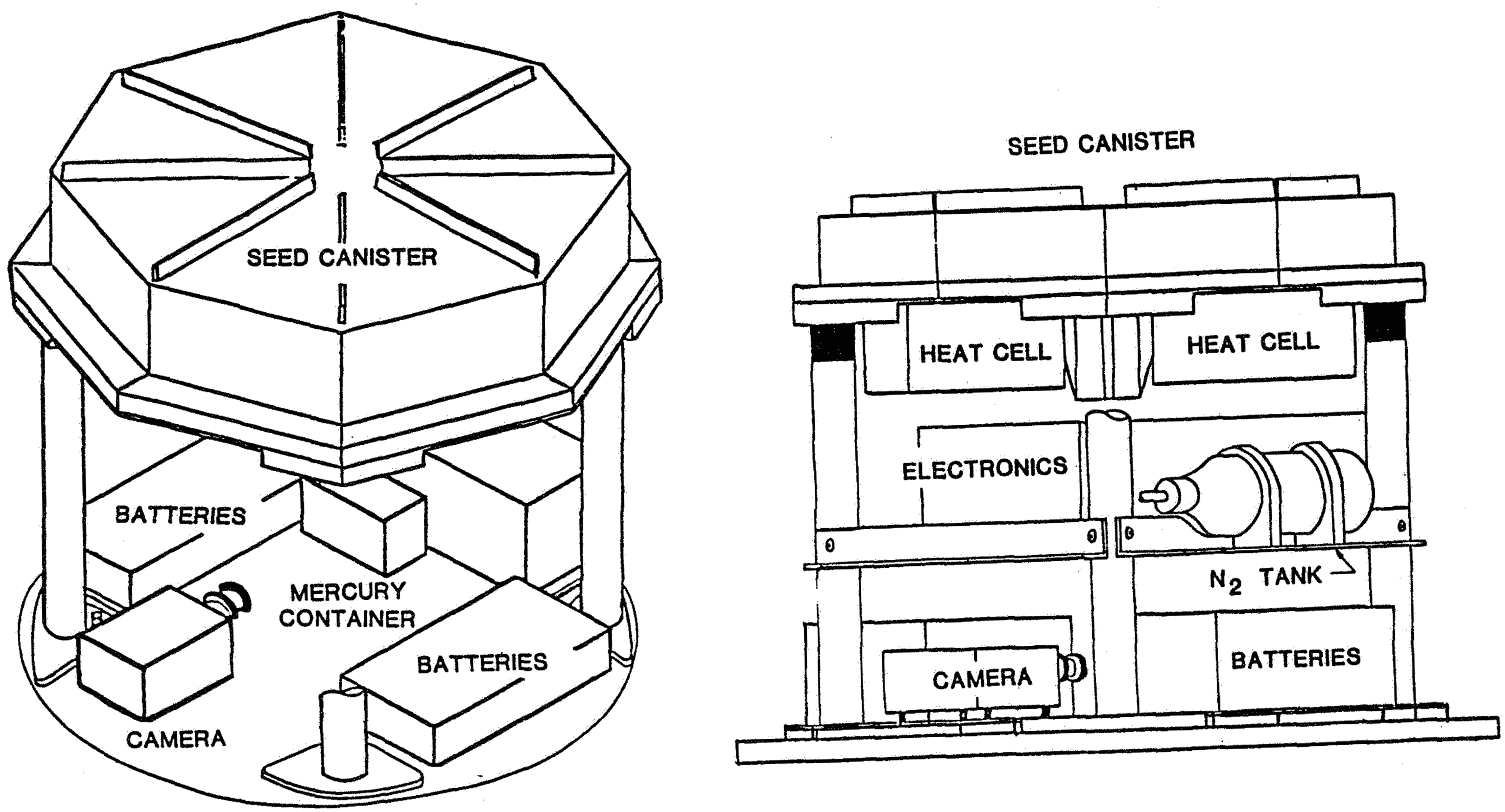
In addition to the primary experiments, other important subsystems included the batteries, temperature control system and the electronic control package which included a Radio Corporation of America CDP1802 microprocessor [1]. All the units were held together by a structural frame Schematics of the payload are shown in Fig. 1.

2. Structural Design

Ascent and landing loads were supported by a structure composed of four cantilever beams fixed to the mounting plate and connected at the free end to the seed experiment canister. Crossbeams connect the cantilever beams and served to carry the experiment subsystems (see Fig. 1). The entire structure is made of 6061-T6 aluminum with a total mass of 7 pounds. With a factor of safety of 1.5 used in the stress analysis, it was found that the structure could support the payload mass of 100 pounds up to 16.3 in a direction perpendicular to the major axis of the Get Away Special container. Vibration tests simulating the space shuttle flight were also performed, and showed that the structure could survive the flight [2]. Inspection of the payload after the flight determined that the frame successfully carried all the components and confirmed the preflight tests and analyses.

3. Thermal Control System

A temperature control system had to be designed to satisfy the thermal requirements of various subsystems. The seed germination experiment was to be kept between 15 and 27^{o}C, and the battery packs needed to be within 15 and 50^{o}C. The microprocessor was allowed a slightly larger range.



a. Perspective view.

b. Side view.

Fig. 1 Schematic of the Purdue University payload.

The final temperature control design was based on thermal models and heat transfer simulations of the environment before and during flight. Outer thermal protection provided by NASA consisted of POMEX felt insulation around the sides and on the bottom of the canister. The upper surface was coated with white paint. In addition to these external blankets, various internal methods were used to maintain the required temperatures. A completely passive control system was chosen, because of the excessive weight and power requirements of other options. The primary component of the system consisted of three custom-built "heat cells" (mfg. TEXXOR, Inc., Omaha, NE). These cells contain a mixture of calcium chloride hexahydrate and Bisol II™ (Δh_{fg} = 221 kJ/kg) that melts at 27°C and have a total heat capacity of 1585 kJ. They act as heat sources and sinks during liquid-solid phase changes. Surfaces of other components were covered with aluminum foil to inhibit or enhance the local radiation exchange. The battery packs, for example had aluminum foil on the outer sides to reduce radiation to the canister wall. A radiation shield consisting of a thin fiberglass shell covered with foil surrounded the seed experiment, heat cells and fluid containers. This shield minimized the radiation to the GAS canister wall, the primary cause of heat loss.

Microprocessor records analyzed after flight showed that both the seed experiment and mounting plate were between 294 and 299°K (21-26°C) from 94 to 145 hours after launch [3]. Note that due to a malfunction, the seed experiment did not operate and was not a source of heat. This differs from the preflight simulation which had assumed an operating seed experiment. Nevertheless, the passive thermal system used in this payload maintained the required temperature range.

4. Particle Detection Experiment

The main component of the particle detection experiment consisted of a stack of 78 sensitive CR-39 plastic sheets stored inside an aluminum container. Each sheet measured 2 x 3 x .025 inches. The sheets on the top and bottom of the stack and the inside walls of the container were coated with a boron paint so that as neutrons entered the container they were converted to alpha particles by the boron. The alpha particles then would penetrate the subsequent sensitive sheets and leave tracks to be detected. Postflight analysis and investigations showed that tracks of particles were indeed present in the sheets [4].

5. Failure Analysis

Inspection of the payload after flight revealed that two of the three experiments (seed germination and fluid dynamics experiments) did not operate as planned. An investigation was performed to find the cause(s) of the problems. Failure of the seed germination experiment to start was traced to an electrical short which occurred when the payload structure was accidentally placed over a wire from the battery pack. This incident happened during final assembly at NASA and appeared at the time to have caused no damage. The inspection made after the flight showed that the heat generated by the short damaged the protection diodes used in the main power supply. During take-off these diodes eventually fractured, and formed an open circuit that prevented electricity from reaching the seed experiment [1].

The reason behind the failure of the fluid dynamics experiment to operate was independent from the problems described above since this system used a separate battery set. A mechanical malfunction of the camera used in this experiment was ruled out as a failure cause since this camera operated before and after flight. Although there is no concrete evidence, a possible source of problems is the film cartridge used by the camera. This cartridge model had several moving parts that could have jammed and prevented the camera from running.

6. Conclusions and Recommendations

Successful designs in the Purdue University GAS-I payload included a structure which was able to support the components during ascent and landing, and a microprocessor which recorded flight data. The thermal control system maintained the required temperatures and data was collected in one experiment. An electrical short which occurred during final installation and possible mechanical problems prevented the operation of the other two experiments.

Based on these experiences and post-flight observations, several recommendations are made here. Systems must be kept simple with as few moving parts as possible. Passive systems are highly recommended. The electronic package should be protected against possible damage and redundant components should be included to serve as backups to important parts. Repeated simulations of the assembly, preflight and flight environments must be performed. These should include vibration tests followed by full scale operation under as realistic conditions (i.e. thermal) as possible. A task group in charge of anticipating possible problem and failure sources should be formed.

7. Acknowledgements

With the exception of some fabrication tasks the entire project was developed by Purdue University students. The author gratefully acknowledges the help provided by the project faculty advisor, Professor John T. Snow (Department of Geosciences), and wishes to thank the donor of the payload reservation, Dr. Harold Ritchey.

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ARC DISCHARGE CONVECTION STUDIES: A SPACE SHUTTLE EXPERIMENT

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ABSTRACT

Gravity plays a significant role in many products, operations and processes, but for many complex systems it is often difficult to separate the effects of gravity from those of other forces and influences. In this experiment aboard Shuttle it was possible to test and examine the gravity-free performance of high intensity discharge lamps. Construction of the experimental payload required careful integration of the structural, electrical and optical systems. Thermal balance and automatic control of the experiment were major issues. The data are expected to yield detailed information concerning the distribution of radiating species in the arc. The distributions are strongly affected by gravity and are the subject of intensive theoretical modeling efforts. The Shuttle data provide unique input to these activities aimed at the development of improved light sources.

INTRODUCTION

A research team at GTE tested three arc discharge Metalarc® lamps in the microgravity environment of one of NASA's small self-contained payloads during the February flight of STS-41B. The project was jointly sponsored by GTE Laboratories, the corporate research facility, and GTE Lighting Products, the manufacturer of Sylvania lamps. The experiment was performed on high intensity metal halide lamps and included the collection of performance data and photography of the arc.

When operated on earth, gravity induces circulation of the hot gases in these arc lamps. That circulation, or convection, affects the electrical and light-producing properties of the arc. These effects, mixed with others, are difficult to separate in ground-based experiments. The observations made while gravity was "switched off" provide verification of theories of arc behavior, clarify the roles of convection versus other processes in the arc, and may lead to potential product improvements that result from altering the influence of convection.

In metal halide lamps an arc is established in an inner capsule, or arc tube, which has metal electrodes protruding through its ends to pass electrical current through the gas inside. The gas is mostly mercury vapor with small amounts of sodium and scandium added to improve the color of the radiated light. During normal operation convection results in segregation of the various species, an effect which impacts the color and efficiency of the light source.

In the Shuttle experiment various properties of the arc were observed with the complication of convection removed. The arcs were photographed to record their general structure and, by means of three bandpass filters, to record the emission from mercury, sodium and scandium. In addition, a record was made of arc current, arc voltage, relative light intensity and arc tube wall temperature.

GENERAL DESCRIPTION OF THE PAYLOAD

The payload, shown in Figure 1, included three separate but identical experimental systems. Three experiments were included for checking repeatability of lamp performance and for redundancy in case of partial failure. There were three lamps symmetrically arranged under the top plate. Each lamp had four mirrors surrounding it to provide multiple filtered images including a white light image. Three 35 mm cameras with extended backs for 250 exposures recorded all images and digital data. A portion of each camera's field of view included a bank of digital LEDs which displayed various operating parameters. Each photograph was, therefore, a composite of these data and the four images of the respective lamp under test. (See Figure 3.)

The power source for both the lamps and the master control circuits was a collection of nineteen battery packs with a total rating of about 4 kWhr. A plug-in card rack contained the three electronic control circuits and electronic inverter/ballasts. The sealed container was filled with 1 atmosphere of dry nitrogen which was maintained throughout the flight.

Each experiment was initiated by an astronaut closing a relay. This closure started the control circuit which, among other things, sent pulses to the camera for taking pictures at intervals of seven seconds. The control circuit also turned on power to the lamp. Typically these lamps take five to eight minutes to warm up and stabilize. Since each experiment duration was 30 minutes, the lamp reached equilibrium well before the experiment was completed.

STRUCTURAL SYSTEM

The cover plate supplied by NASA had 45 tapped holes and could not be modified. The lamps with their mirrors and filters were attached directly to the cover for optimal heat transfer. Three columns at 120° intervals were also attached to this plate at the outer perimeter with three screws each. The columns, about 10 inches long, supported a full diameter shelf. The three cameras as well as the digital display panels were attached to this shelf. Three additional columns, about 13 inches long, were attached to the opposite side of this plate and supported a second shelf. A card rack for plug-in printed circuit boards was located between the two shelves. A non-metallic battery compartment was integrally attached to the far side of the second shelf.

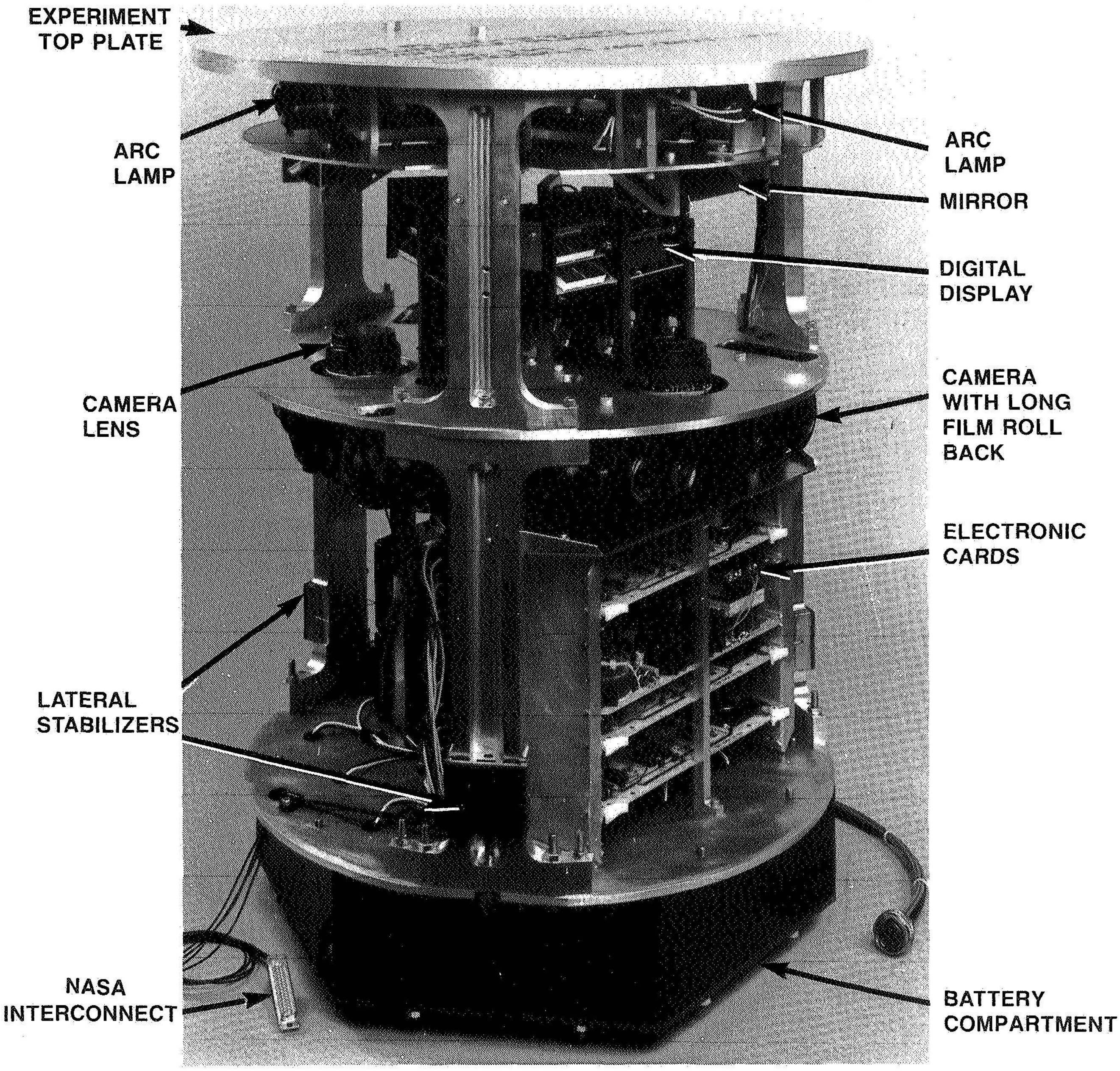


Figure 1: The Payload for the Metal Halide Lamp Experiment.

Three adjustable lateral support pads, shown in Figure 2, were mounted on the three lower columns in line with the center of gravity of the suspended payload. Thus, the inertial forces generated during transverse oscillation were largely transferred through the pads to the wall of the container. These pads were adjustable from the open bottom of the container by means of a jack screw which translated a ramp under the pad. This design was quite simple and compact and permitted location of the lateral support pads at any arbitrary position along the payload to line up with the CG if desirable.

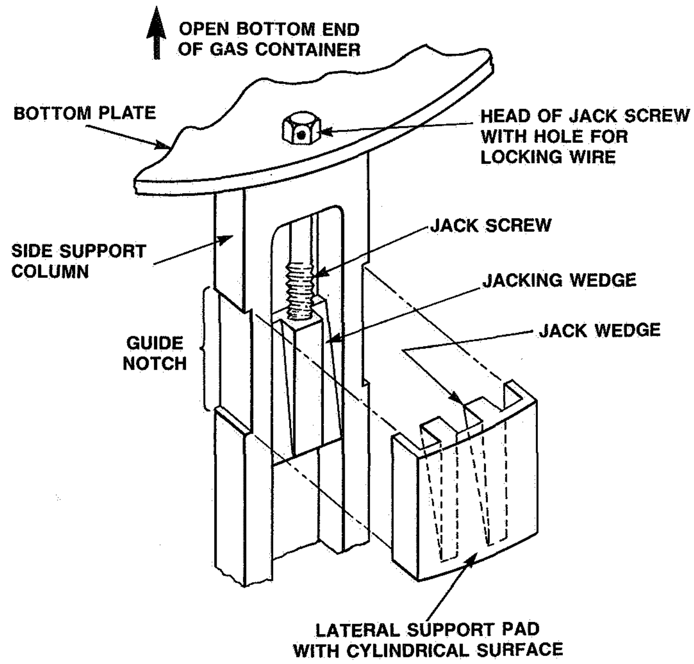


Figure 2: Detail of the Lateral Support Pad.

PHOTOGRAPHIC AND OPTICAL SYSTEM

The only instruments of data collection used in this payload were Nikon F3 cameras. The cameras were equipped with alkaline battery powered motor drives, and were outfitted with extended backs which accommodated 38 foot rolls of film for over 250 exposures. By including the digital display of measured data in the cameras' field of view the overall problem of data collection and synchronization was greatly simplified, and any doubt about the relationship in time between the arc photographs and other data being monitored was eliminated. Since each frame on the film contains a complete instantaneous record of data, coordination of the analysis is simplified.

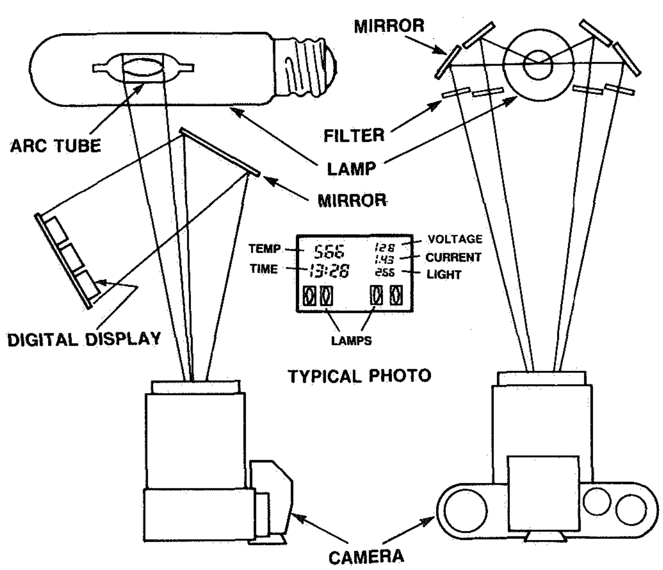


Figure 3: Two views of the Photographic Optical System.

The camera was tripped once every seven seconds so that 256 exposures were made during the 30 minute test. As shown in Figure 3, each lamp was outfitted with four mirrors to provide four virtual images falling on a common plane for sharp focusing. Each of these images was covered with a different narrow band filter to isolate mercury, sodium and scandium radiators in the arc. The fourth filter was of neutral density to adjust the white light image for equivalent exposure. All mirrors used in this assembly were front surface, and some had selective coatings designed to reduce the energy which must be absorbed by the filters.

The six channels of data being displayed on the digital panel were projected to the camera by another larger mirror. Lamp voltage, lamp current and photopic light output were displayed on digital voltmeters. (Photopic light characterizes the spectral response of the human cone receptors. It was simulated with a photopic absorption filter in front of the photodetector.) During DC operation the lamp voltage polarity was indicated by a plus or minus sign on the display. A digital thermocouple meter displayed temperature of the arc tube as detected by a chromel/alumel thermocouple. A clock was installed to display elapsed time starting with zero at the moment of startup. All displays used LEDs for uniform photographic brightness throughout the experiment. The LEDs were blanked between camera exposures to conserve power. They were also held in the fixed-display mode during exposure so that changes in digital reading were not ambivalently recorded by the camera.

The film used was Kodak Technical Pan 2415, a universal film on a highly stable Estar base which can be developed in a variety of ways for different speeds and contrasts. The selected processing resulted in a very long and linear exposure range which could accommodate the wide brightness range encountered during startup as well as the uncertain brightness level to be attained in the microgravity environment. A photographic step wedge was pre-exposed on the film for calibration of density measurements of the arc images. This wedge was included on a blank strip at the head of the film and at periodic intervals throughout the film. To prevent the calamity of losing an entire roll of film during processing, the film was cut into five foot lengths and developed separately in conventional developing tanks. The developing process was controlled as closely as possible to keep all sections at similar density, but the local step wedges serve as a final reference for the precise density.

ELECTRICAL SYSTEM

The power source for this payload was a set of alkaline manganese dioxide cells connected in a series/parallel configuration. The cell used was a size F, manufactured by both Duracell and Union Carbide, and is available in multiples incorporated in consumer lantern batteries. This primary cell has an excellent performance record, very long storage life, moderately high energy density, good low temperature performance and low cost. At high discharge rates it has a sloping discharge, and since it is non-rechargeable, additional sets of batteries were required during pre-flight testing. The cell is vented to eliminate the potential for an explosion. During short circuit tests of single cells, the temperature rose about 70°C, but no noticeable release of gas or slurry was observed. Temperature rise during the normal discharge rate of under 2 amperes was about 2°C.

The battery construction, shown in Figure 4, uses seven cells in series, and a 7-ampere fuse. The fuse was located between cell numbers 2 and 3 so that not more than one cell could be included in a case-to-case short without including the fuse. Four of these battery packs were connected in series to develop the required voltage, and four such series strings were connected in parallel, using diodes, to supply the required current. Three separate 7-cell batteries were used individually for powering the timing control circuits. These latter cells were respectively switched on by the relays in the NASA Control Decoder to initiate each experiment. The 19 batteries were installed hexagonally close-packed in the hexagonal battery compartment with their leads passing straight through individual grommeted holes in the lower shelf.

The schedule of the experiment was designed to simplify design and operation of the timing circuit. All events occurred at simple geometric multiples of the seven second camera cycle. At the 15 minute point (128 x 7 sec) the lamp power switched from 60 Hz square wave to DC. The DC polarity was reversed every 112 seconds (16 x 7 sec). An optional function was to modify power levels at intervals of 7.5 minutes (64 x 7 sec.). The entire experiment was completed in 30 minutes (256 x 7 sec) at which time all power was turned off.

This mode of operation permitted the use of a simple circuit consisting of a clock set for 7-second pulses, a counter with outputs at geometric multiples of the 7-second input pulse and various gates and buffers for outputs. Simplification helped to maintain a high level of reliability.

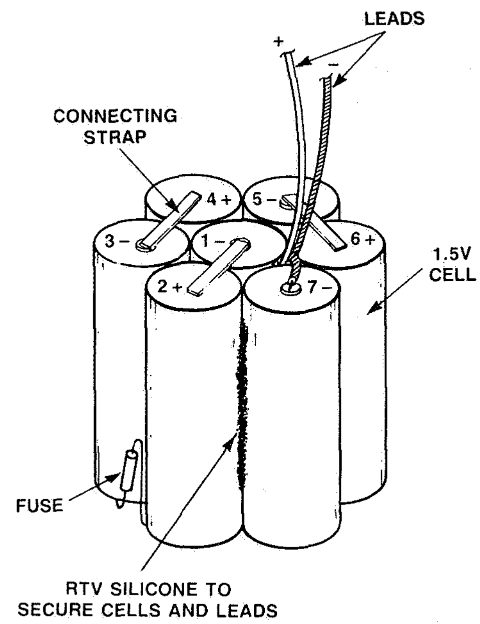


Figure 4: Detail of the 7-Cell Battery Pack.

Discharge lamps require a series ballast to limit the current after the arc is established. Ballasts for AC operation are typically inductors. This experiment required DC to AC inversion, high voltage starting pulses to guarantee startup and current-limiting during DC operation. An electronic ballast circuit was designed which incorporated all these functions. This circuit utilized a commercial CMOS regulating pulse width modulator and specially designed inductors. The regulation was excellent with less than 1% variation in current for a DC supply voltage ranging from 43 down to 22 volts.

The lamp under test was a standard 175-watt Metalarc® lamp manufactured by GTE with a slightly modified fill. It was mounted in a slender evacuated outer jacket to minimize the size of the optical system with its four mirrors and filters. It operated at 135 volts and drew 1.3 amperes. The outer jacket of the lamp was supported at each end in a V-block type cradle with a spring to secure it in place. This arrangement was designed to minimize stress on the jacket thereby reducing the chance of breakage.

THERMAL CONSIDERATIONS

The first Get Away Special payload flown on Shuttle was an instrumented package made by NASA for gathering information about the container design itself. A number of temperature curves were obtained from this payload. Although the external portions of the container experienced wide excursions in temperature as the shuttle changed its orientation relative to the sun and the dark sky, the internal temperatures remained relatively stable. The instrument plate, the battery box and the tape recorder all rose a few degrees upon takeoff to about 30°C then slowly cooled about 5°C per day. This experimental payload also had some heat dissipated into the top mounting plate at three different times during the flight. These dissipations were 160, 330 and 320 watt-hours respectively. The plate heated about 10°C at most while other components experienced very little temperature rise.

Since our payload was to dissipate only about 100 watt-hours on three different occasions with many hours between them, heat rise problems did not appear to be severe. Calculations indicated that even if all the energy from the lamp was absorbed by the end plate, the temperature rise would be about 33°C. If this heat were to distribute uniformly throughout the payload, with no losses, the temperature rise of the payload would be about 5°C. As a result of these expectations, it was decided to outfit our payload identically with that of the test payload, i.e., to utilize an anodized mounting plate covered with insulation. This insulation was also expected to help prevent the batteries from cooling excessively. In the hope of maintaining the batteries above 10°C, the experiments were requested to be performed as early in the flight as possible. Heat rise of the batteries during normal use was measured to be about 2°C.

Since natural convection is absent in the microgravity of orbit, small fans were provided to circulate the nitrogen atmosphere over the circuit boards. These were not only provided for the obvious sources of heat such as power transistors, but for other components such as resistors which have short thermal time constants and may have experienced considerable heat rise with little more than diffusion and point contact conduction to cool them.

The glass mirrors and filters were mounted in such a manner as to leave them free to move relative to their metal supports to prevent risk of breakage due to thermally-induced expansions of the components.

TESTING

NASA recommended a single vibration test which effectively tested for noise and acceleration. If the test were not performed, a more conservative stress calculation was required. A finite element stress analysis of the structure was performed during design of the payload. The vibration test was performed on subassemblies early in the project as well as on the completed payload. Although not required, the test was, nevertheless, performed primarily to uncover potential weaknesses which would jeopardize the success of the mission. The payload had been designed using conservative practices—low stress levels, multiple screws with locking devices, oversized cables well supported with clamps, glass components mounted on cushions and retained with springs, etc. The payload suffered no physical damage during launch and orbit.

RESULTS AND CONCLUSIONS

The payload was retrieved within 2 weeks of the landing at Kennedy Space Center. Examination unveiled no damage to the payload and subsequent processing of the films revealed that all three systems performed nearly to perfection. The integrity of the structural system and the performance of the automatic electrical systems indicate that the basic design is sound. Modification of this design to accept various future experiments can be readily effected.

Film processing was carried out in stages to ensure that development of the analog arc images resulted in optimal data acquisition. Linear radial scanning at selected arc axis positions produces quantitative data for the mercury, sodium and scandium emissions. Determination of the radial arc temperature profile from the scanned image of mercury intensity and determination of species density distributions are in progress. These analyses require absolute calibration of film densities as a function of radiated power and complex computer aided inversions of density distribution data.

Evaluation of digital film data shows that the 175 watt Metalarc® lamp has a significant increase in light output when convection is removed in the gravity free environment of this experiment. This increase in efficacy is due to a more uniform temperature and radiating species distribution. Operation under DC power reveals sizable cataphoretic effects that are being studied further.

ACKNOWLEDGMENTS

Thanks are due to Dr. Joseph Proud and Dr. Timothy Fohl for initiation and support of this program. Valuable discussion with Dr. Harold Rothwell and Dr. Gerald Rogoff, members of the research team, are also gratefully acknowledged.

SPACESCAPES/PAYLOADS FOR THE ARTS

By Joe Davis

ADMINISTRATIVE AND TECHNICAL ASPECTS OF THE NEW WAVE RUBY FALLS GET AWAY SPECIAL PROJECT ARE REVIEWED IN PERSPECTIVE

Introduction:

The first efforts to involve NASA and space shuttle in projects for the arts were, by and large, disastrous. Artists had a hard time understanding their role in contending with technical benefit requirements of the program and, further, they typically expected money to flow in the wrong direction, thus compounding the problem. One of the few (if not the only) NASA offices actually accustomed to paying independent, or free-lance artists was the Office of the Graphics Coordinator at NASA Headquarters, which is where many artists with would-be shuttle projects eventually ended up, and were of course subsequently dismissed. NASA has not been historically inclined to recognize the arts from the standpoint of practical benefit, save perhaps in the context of the usefulness of the graphic arts to document programs and procedures for books, charts, brochures, and other materials either for print or broadcast. Unfortunately, it seemed as if the inherent utility of the arts might remain submerged in the fabric of such a narrow application. To NASA, space was strictly business; the place for serious and justifiable (in Congress) research. Meanwhile, to the artist, space was the place for works of enormous power and scale; a stage for the struggle with gravity which has always stood between the sculpture and the sculptor; even between the fresco and the floor, and now, between the artists and the artist's vision. It wasn't the Graphics Coordinator's job to hire on artists with projects for the space shuttle; and in the transition from landscapes to spacescapes, artists weren't presenting themselves as potential customers, submitting earnest money, or otherwise substantially contributing to positions in which they could be treated according to the same policy and regulation as other commercial users.

NEW WAVE RUBY FALLS:

As the need for a negotiable commercial relationship had become more apparent, earnest money was submitted in July,'78 for a 5 ft.^{3}/200 lbs. GAS payload that would eventually become NEW WAVE RUBY FALLS. Accompanying correspondence described the payload as a "unique science/art juxtaposition that will satisfy technical, and 'human benefit' criteria which NASA requires for small, self-contained payloads".

While it has become technically possible to create works of art on an enormous scale, art itself is becoming as societal as it is monumental. Where prospective works of art could involve large sums of money, thousands upon thousands of work-hours, and support systems that include agencies of the government, artists are finding - in some cases, for the first time - that they are being asked to resolve the practical issues of that participation.

By December, 1978, NASA was still uncertain, and an offer was made to refund the earnest money untill a decision was reached to "...permit this class of payload to fly,..." Again, by return mail, the issue of technical benefit was addressed, and this time, with some direct reference to the principals of free enterprise:

"...Still, remembering that NASA has its deepest roots in the American free enterprise system in general, and in uncounted hosts of fiercely competitive support contractors, janitors, clerks, and artists in particular, it is surprising that NASA has not decided to grant a fair and equal opportunity to any and all of the above who could develop a meaningful, ethical payload, and pay the same price as other STS customers...

...When we consider the relative benefits of typical shuttle payloads, even if we choose to ignore the history of underdeveloped peoples whose lives have been destroyed or severely exploited as a part of the planetary cost of technical advancement, at least we can agree that the history of human suffering, and the depletion of natural resources has had little or nothing to do with art. Indeed, if the priorities for allotting shuttle payload space allow for projects that contribute to the improvement of the human condition and the quality of life, then the arts represent a very humane and universal practicality...

...Even if the existing priorities relate exclusively to technical research and development, it should be remembered that many of the technical advances vital to our way of life are, in fact, directly attributable to development in the arts. A few among these are the invention and development of practical photography(including the basic camera and photographic plates); lost wax casting, lithography, silk-screen printing, pigments chemistry... all of which technology as we know it could do little without... The point is that technological development is not, and has not traditionally been the private domain of science and industry...

...I do not expect or desire a refund unless there actually is a decision to specifically prohibit art, even in payloads that comply with prescribed technical criteria..."

- letter to STS Operations(1/8/79)

Some ten months later, NASA decided to accept the earnest money based on compliance with the policy for scientific research and development. In a letter dated Oct. 23, 1980, the payload was finally assigned an official payload number(266A) in the earnest money queue. The NASA/customer relationship was thereby legitimized, and lines were drawn on the matter of what could fly, and what could not. NASA would neither qualify or disqualify a project simply because it contained or pertained to a work of art, though clearly if the artistic and scientific aspects of such a payload could be at all separated, then NASA would fly the science and not the art. Here integration of sensibilities was as important as integration of hardware; and the commitment to develop and administer to this integration was no doubt an equal challenge to both worlds.

At this time NASA was still formulating key elements of the GAS program. The GAS Final Rule, GAS cannister dimensions and structural characteristics, facilities for an opening end, optical window, and the contingency for deploying GAS payloads were all among the issues yet to be resolved. It follows that the nature of these uncertainties would figure significantly in forthcoming proposals. Accordingly a variety of technical applications were assessed so that the project could cope with anticipated variables in final determinations about payload 266A, and GAS payloads in general. Such diverse areas as space inflation technology(inflatables), foam-metals techniques, vacuum welding, laser-interferometric and holographic-interferometric gravitational wave detection, Earth-resource imaging and reconnaissance techniques, crystal growth and semiconductors ... were analyzed with respect to feasible interfacing of artistic and scientific objectives.

Although there was no requirement to do so, copies of drawings and abstracts from the aforementioned explorations were forwarded to STS Operations and presented at GAS-user symposiums, etc., over a period of several years. Payload 266A was thereby pursued in terms of alternatives so that options were switchable in the face of administrative and/or technical dead-ends; and it was also intended that at this point a rejection or disqualification of the payload would be discouraged on the basis of a single possibility.

GAS payloads can, and in fact already are used to create small amounts of new and unique materials with implications that are as artistic as they are scientific; having ultimately as much to do with the arts as paint and marble do now. Foamed metals could be used for instance, to create very lightweight and tenuous, yet extremely strong bases for massive, weighty objects...foamed gold or platinum would have as many scientific uses as uses in lapidary and sculpture; likewise for payloads devoted to the manufacture of ultra-pure semiconductors(saphires, garnets) and ruby rods for lasers. The final disposition of such payload products may present some problems for the artist-user however, as NASA has rejected payloads it feels would take unfair advantage of public resources by producing non-technical financial 'killings' on the open market. NASA has thus rejected proposals for payloads that would fly stamps, coins or medallions, prints, and even crematorial ashes, on the basis of preventing what is obviously considered unethical entrepreneurial activity at the expense of the federal government. An artist 'cashing-in' on a relatively miniscule investment, or one who plans to do so, might similarly provoke the ire of the space administration in such a way as to inspire regulation that could effect the entire community of the arts. What portion of such a payload would be used for art; and what part for research? How would products thereof find a fair price and a fair market?

Due to the complexity of these issues; and because of artistic motivation to involve the site itself, as well as the mere characteristics of the site, concepts for payload 266A moved more toward schemes for shuttle-based environmental art. In an early proposal made by the user in connection with Dr. Leon Goldman(Director of the Laser Laboratory at the University of Cincinnati Medical Center),the GAS container would be used, possibly with a sub-cannister, to discharge 5 ft.^{3} of crushed glass, shreaded aluminum foil, and UV-activated phosphors. The idea was to use ground-based lasers targeted on the discharged materials to create spectacular displays of light and color visible to large numbers of observers on the ground for both artistic and scientific purposes. Observations of atmospheric absorption, refraction and beam divergence could be made for a variety of lasers operating at different places on the visible, and ultra-violet parts of the electromagnetic spectrum. Also, drift and diffusion of the discharged particulate could be observed and measured. Again, there were certain problems.

Although NASA had not unconditionally decided to prohibit deploying GAS payloads on the long term, they had decided that there would be no deploying GAS experiments on the short term. Machinery to facilitae deploying experiments was at this time still in the process of design and testing, and users were warned of additional high costs which would probably become associated with deploying payloads.

Because of potential interference with other payloads, and with ground-, and shuttle- based astronomy, NASA was reluctant to encourage the GAS-related deployment of any particulate or solid materials whatsoever.

In any case it was evident that the GAS cannister of maximum weight and volume could not contain a materials-intensive environmentally scaled experiment, artwork or not. Indeed, a GAS cannister could only contain part or portion of continuous physical objects much larger than at best, a few score meters(as in the case of inflatables). Consequently GAS experiment/environmental artworks conceived of as works with light represent an adaption to the confusing relationships of scale seen in the utilization of a 5 $ft.^3$ space in a high speed global trajectory. Light has long since been common ground to the interests of art and science; is weightless; not restricted by physical connection to any particular space or area; will not outgas or physically contaminate other experiments; and is not adversely affected by vacuum, temperature extremes, vibration, G-force variations, or any other known characteristic of the near-shuttle region.

Light in the context of environmental art is nothing new, neither for that matter is the overlapping technical interest. For decades, and in some cases for centuries, artists have employed mirrors, lasers, projectors, searchlights, pyrotechnics, etc., to create large-scale public works. The interdisciplinary works of Rockne Krebs, of Washington, D.C., and John David Mooney, of Chicago, Ill. are contemporary examples. The late Alexander Calder, artist of 'mobiles' and 'stabiles' fame(who also painted Braniff jetliners) had collaborated with Dr. Goldman at Cincinatti to determine the feasibility of placing mobiles in space which would interact with lasers based either on-orbit, or on the ground. This was some time before the start of the GAS program, and Calder died unfortunately before he had time to work out other possibilities. Still other artists, mesmerized with shimmering auroras produced in many years of rocket-borne investigation of the ionosphere and the earth's magnetic field, have proposed the creation of auroras for artistic purposes by the pyrotechnic/chemical release, and other methods heretofore employed by scientists associated with auroral experiments in rocketry. Regrettably, the cost of such a project, owing to the need for an expendable launch vehicle and support systems, can easily range into figures unaffordable by any individual artist, even if the artist in question happened to be an extremely wealthy one, and even if associated government agencies had offered their cooperation, which they had not. The fact remained that technology necessary for the production of artificial auroras would be prerequisite if large -scale atmospheric lightforms were ever to become a medium for envronmental art. In the context of GAS payload 266A, given both the widespread scientific and technical interest, and the breakthrough economics of the GAS program, an auroral payload concept began to take form.

One possibility would have been to propose the deployment of Barium triple-carbonates, and other materials used in conjunction with pyrotechnic/chemical release <u>without</u> the pyrotechnics in subcontainers designed to quickly disintegrate on reentry; allowing for the ionization of materials solely by atmospheric heating. It is fair to assume a more favorable response from the space administration to payload concepts not pertaining to the use of plastic explosives, thermite, or other pyrotechnic materials, especially in view of the sensitive and tenuous issue of deployment of anything at all. And, although the user(s) has described an option for the use of one or two such subcannisters in the NEW WAVE RUBY FALLS payload accommodations requirements, launch agreement negotiations, etc., the inclusion of such subcannisters have been proposed only optionally, as the user pursues a higher order of compromise on the matter of deployment.

Natural auroras have been associated with surges of electrons in the ionosphere which, in turn, have been associated with solar activity. Mimicking this natural process, scientists have used electron guns as surrogates for solar and magnetospheric activity to introduce beams of electrons into the environment under controlled conditions. An electron gun consists of a cathode(-), which consists of, or is coated with an electron emitting substance, and anodes(+), which focus and/or collimate the electrons, and determine the voltage(energy) of the electron beam. The amperage or current density is work function of the cathode which is usually heated to the specific temperature at which desired emission takes place. Electron guns have been used for a variety of purposes with and without chemical release materials in sounding rocket, as well as deep space missions, and two have flown in large, non-GAS shuttle experiments to date. Although the two guns involved in experiments carried out on board shuttle(OSS-1's Fast Pulsed Electron Gun on STS-3; and the SEPAC experiment on STS-11) were not necessarily intended to produce emissions visible to observers on the ground, the problem of determining the characteristics of an electron gun intended to produce visible auroras is an eminently solvable one; and the road to that solution has benefited greatly by the fruits of earlier investigations. It was with this project in mind that NASA signed a standard launch services agreement to fly GAS payload 266A, NEW WAVE RUBY FALLS; the first launch agreement signed for a payload containing, or pertaining to a work of art, and the first private sector payload launch agreement for a GAS payload intended to at least partially deploy. That signing occurred May 4, 1982 nearly four years after the original submission of earnest money. On June 8, 1982, the user reserved two additional payloads under the auspices of the Center for Advanced Visual Studies(payload identification numbers 439 and 440 in the earnest money queue) for future payload projects.

One of the first determinations made of the 'RUBY FALLS experiment parameters derived from published observations of natural auroras.

In the process of documenting auroral observation, international brightness coefficients were established to standardize references to intensity of brightness. International brightness coeffecients are incremented in terms of Rayleighs, a standard of brightness which is in turn translatable into photons per sq. centimeter per second(i.e., 1 Rayliegh = 10^6 photons $^-cm^2$ ^-sec. at 5577 angstroms, a green emission line in oxygen). Further, the brightness intensity of minimally visible auroras(so called 'diffuse' auroras) has been established as having an international brightness coefficient(IBC) of 1, or 1 kilorayleigh. Thus the brightness of minimum auroral visibility can be expressed in terms of oxygen emissions as 10^9 photons $^-cm^2$ ^-sec for auroras which normally occur at an altitude of about 100 km. 'RUBY FALLS' parameter for minimum visibility was thereby established, as well as an ideal target altitude of 100 km, in the electrically active auroral zone.

The next step was to determine what output levels of current and energy were required so that the 'RUBY FALLS electron gun could produce the prescribed auroral brightness, and penetrate to the preferred altitude. Fortunately, these values were also calculable in terms of extensive earlier investigations.

In the process of ionization and recombination, atoms of gas emit photons with a frequency or 'color' that directly corresponds to the amount of energy consumed by the atoms at the start of the process. When an atom of gas absorbs energy from its environment, an electron can move to a higher energy level. Once in the higher level, the electron tends to return quickly to the original energy level. In this downward transtition a photon with an energy nearly equal to that of the energy absorbed in the upward transition is released. A photon is released when an electron moves from one of the allowed energy levels in an atom to a lower level. Such electron series transitions are predictable according to the species and density of gasses involved, and the amount of incoming energy. Visible(Balmer Series) emissions in atmospheric gasses at 100 km(auroral zone) would correspond to an output of 1.6 amps at 6 kv for the RUBY FALLS electron gun according to the conclusions of the 'RUBY FALLS research group. In order to allow for a significant margin of error, a 10 amp/10 kv gun is proposed which correspond to atmospheric emissions with an international brightness coefficient of three(IBC-III), or three times minimum observable emission.

Based on a 28 volt/40 amp-hour power supply, the 'RUBY FALLS electron beam will be pulsed at 1 millisec/1 sec. during discharge sequences over night sky through one to several consecutive orbits. Again, given a 50% margin of error, approximately 3000 individual millisecond pulses should be possible according to current estimates; including 225 watts of cathode heating power. 3000 IBC-III rated emissions are therefore anticipated.

The process of acquiring specific payload hardware and support services for the NEW WAVE RUBY FALLS project has matched technical challenges with significant economic ones. Due to thoroughly interdisciplinary project characteristics, NEW WAVE RUBY FALLS has not been fundable by foundations or endowments designed to support either the community of the arts, or the sciences. In the larger view, the lack of, or dwindling scale of traditional support for the arts and sciences reflects the society-wide economic condition of course, and the special nature of the 'RUBY FALLS project merely amplifies that effect. Still the economic principal of such a situation is that a shortage of currency accompanies a surplus of goods and services. With respect to this surplus, coincident interests were established with corporate and government sources of 'RUBY FALLS-required hardware and services in order to form the basis for practical relationships with product development and market research groups in industry, as well as with research communities associated with government agencies and academic institutions. Likewise, emphasis has been placed on utilization of existing services and available, off-the-shelf hardware(when at all possible) in order to foster containment of time and costs in the development and testing phases of the project. The attention of the press has also figured significantly in developing relationships with project support by disseminating information which has helped to instigate those relationships in the first place, and by representing public-relations/advertising benefits to companies participating in a project with extensive media visibility. Companies currently cooperating in the NEW WAVE RUBY FALLS project include EG&G CORPORATION, Electronic Components Div., Salem Mass; KILOVAC CORPORATION, Santa Barbara, Calif.; TRI-CON INC., Cambridge, Mass; G-TEK INC., Waveland, Miss; STRUCTURAL COMPOSITES INDUSTRIES, Pomona, Calif.;...(partial listing). Additionally considerable testing support, as well as extensive reference and consulting has been provided by the Space Physics section of the Air Force Geophysics Laboratory at Hanscom AFB in Bedford, Mass.

It has not been the user's intention in compiling this account to imply that all of the problems associated with the NEW WAVE RUBY FALLS project have been solved, for certainly they have not. On the other hand, some of the issues approached - and resolved - with regard to reconciling the antagonistic sensibilities of the cultural and technical worlds have never been resolved before. One of the benefits of the project is that technology has been represented with a certain integrity as an interdisciplinary resource. 'RUBY FALLS will help to express the fact that, especially in America, technology is both accessible and adaptive; and by expanding what is generally held possible for an artist to do, it is about the right to make a difference.

Crystal Growth of Artificial Snow

Shigeru Kimura, Akihito Oka, Minoru Taki(Asahi Shimbun Co.)
Ryushi Kuwano, Hiromi Ono, Riichi Nagura, Yoshito Narimatsu,
Jun Tanii, Yotsuo Kamimiyata (NEC Corp.)

The Asahi Shimbun Co.,the leading newspaper company of Japan, did GAS experiment twice in 1983 and succeeded in observing the growth of artificial snow crystals under weightlessness.

The snow crystals grown onboard the Space Shuttle were polyhedrons looking like spheres, which were quite unlike snow crystals produced in experiments on the earth.

§ DEVICE FOR THE EXPERIMENTS

The heart of the device for the experiments is two copper boxes, each 4 cm in both depth and width and 10 cm in height. On one side of each copper box, semiconductor thermo-modudules(cooling units) are attached. The thermo-modules can lower the temperature in the box to −15 degrees centigrade in about 10 minutes. On the top of each copper box is a water container made of porous sintered metal which is similar to a sponge. In the water container is a electric heater to vaporize the water at about 25 degrees centigrade.

As shown in the Figure 1, there is a heater to sublimate silver-iodine, fine particles of which serve as seeds for snow crystals.

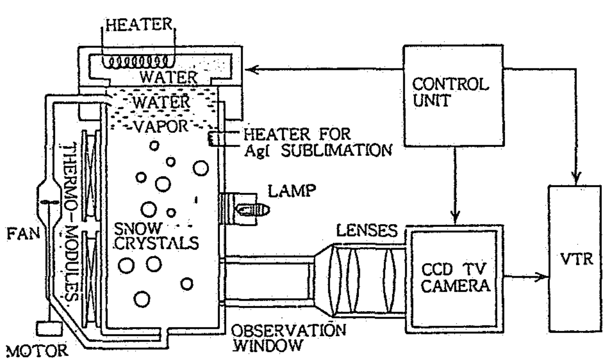


Figure 1. Structure of the artificial snow experiment.

There is a observation window on the other side of the copper box, through which the snow crystals are observed with TV cameras and recorded onto video-tapes.

For the first experiment in April, the above-mentioned device was used.

But after the failure of the first experiment, small fan was attached to the copper box in order to see the effect of air flow in the box on the growth of the snow crystals.

For this device,four CCD TV-cameras

and four VTRs are used which are all for home use. Thus we have verified that some inexpensive hardwares for home use can be utilized for GAS experiments.

Some characterics and features of the device are shown in table 1.

TABLE 1

Size	Diameter: 50 cm
	Height: 70 cm
Weight	90 kg
Subsytems	2 identical subsystems
Capacity of Water Container	15 grams
Power Supply	Ni-Cd Batteries
Field of View	4.8×6.4 mm
	1.2×1.6 mm
Resolution	10 microns
	3 microns
Recording Time	2 hours/1VTR

§ RESULT OF THE EXPERIMENT

(1) First Experiment

The first experiment was carried out on STS-6, which was the first flight of the Challenger and was launched on April 4,1983.

But the VTRs failed to record any snow crystals. The post-flight investigation revealed that the coldness of the space lowered the temperature inside the GAS canister to − 7 degrees centigrade. Thus the water in the container was frozen at the start of the experiment. The heater inside the container was of only 1 watt, so the temperature of the water could not be warmed up to 25 degrees centigrade. The experiment was repeated for four times but even at the last experiment the temperature of the water was about 7 degrees centigrade.

It was inferred that, as a result, the amout of the water vapor generated was small. Thus snow crystals were not formed. And it is also suspected that the lack of thermal convection under weightlessness prevented the water vapor to travel 60 mm distance from the exit of the water container to the field of the view of the observation window.

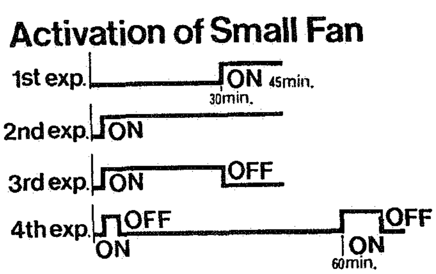


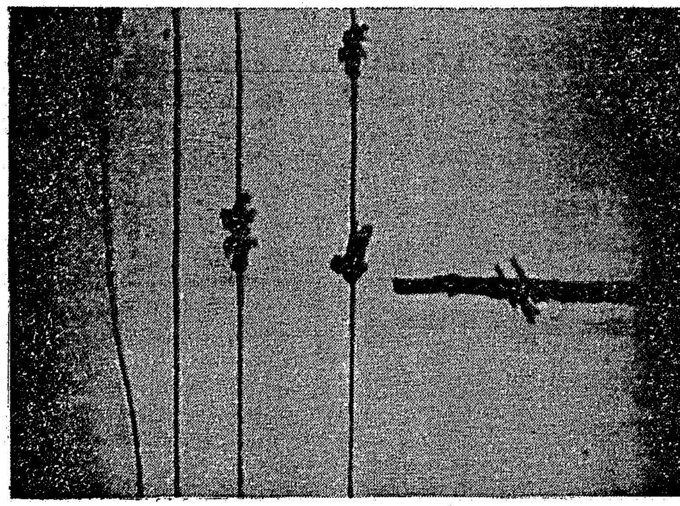
Figure 2.

So the device was improved. The power of the heater was raised up to 4.5 watt and an auxiliary fan of a blower type was installed in each box. The diameter of the fan was 1.5 cm. By turning this fan on and off, the comparative studies were conducted.

The experiment was repeated twice for each box, tatalling four times. In each experiment, the mode of activation of the fan was changed as shown in Figure 2.

(2) Second Experiment

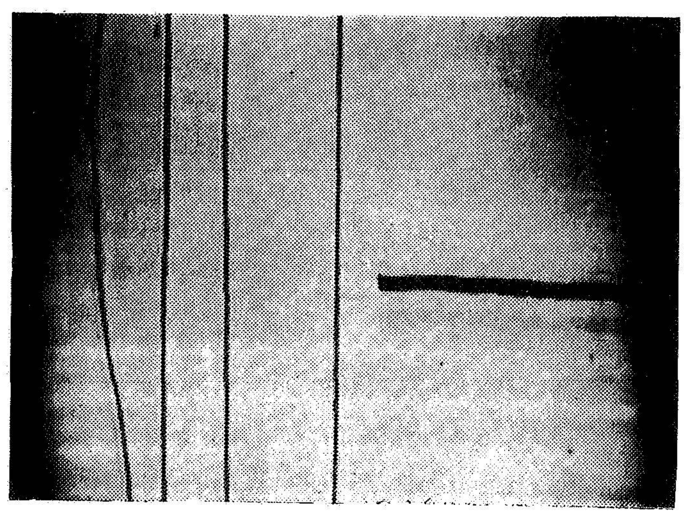
The second experiment was carried out on STS-8, which was the third flight of the Challenger and was launched on August 30, 1983. This time the experiment was successful. The results of the experiments was recorded on four video cassettes with a tatal time of about six hours and 50 minutes.



In the second and third experiments, in which the auxiliary fan was activated to make an artificial breeze for the most of the experimental time,hexagonal and irregularly shaped snow crystals were formed on the four rabbit hairs which were installed in front of the observation window in order to catch the snow crystals. And frost was formed on the copper wire which is also installed in front of the the observation window in order to investigate the growth of the frost. The results of these two experiments were just as same as the results of the experiments which were carried out hundreds times on the ground. One of the result of the third experiment is shown above. Four vertical lines are rabbit hairs and a horizontal line is a copper wire .

But the results were different in the first experiment, in which the fan was not activated for the initial 30 minutes and thus the weightlessness was maintained, and in the fourth experiment, in which the fan was activated for five minutes when the silver-iodine was sublimated and then the weightlessness was maintained for about 50 minutes.

No changes appeared when the fan was not activated in the field of view of the TV-cameras as shown in the picture (Right).

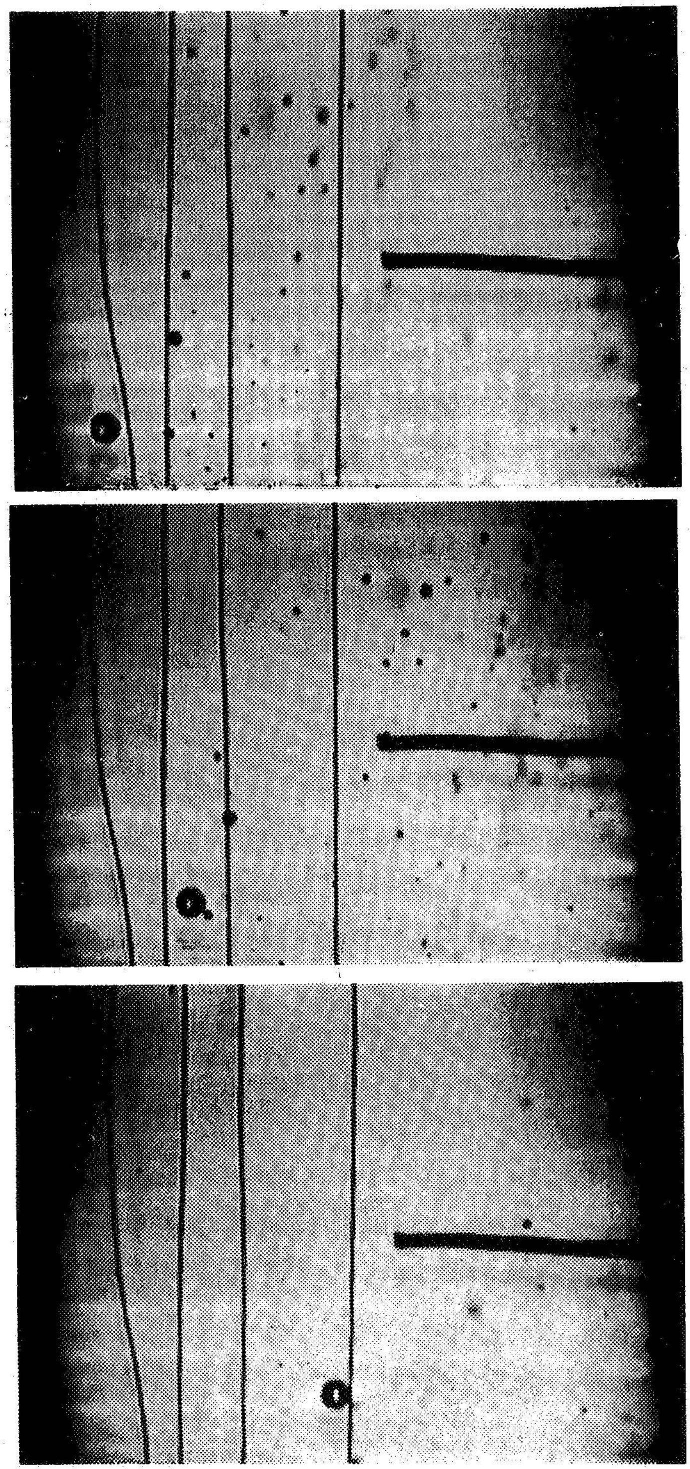


But as soon as the fan was activated, crystals of artificial snow, which were reasonably supposed to be formed and grown under weightlessness, were brought into the field of view of the TV-cameras by the breeze the fan made.

The crystals were almost spherical looking like a ball. The diameter of the largest crystal was about 3 mm.

One crystal traveled the fieled of the view from left to right and finnally collide with a rabbit hair. At the collision the shape of the sphere was not changed. Thus, it was confirmed that the sphere was not a water droplet but a snow crystal.

One scene of the first experiment is shown in serial pictures on this page.



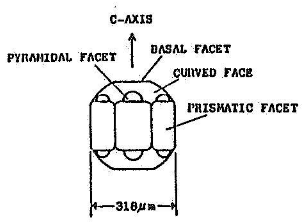


Figure 3.

Dr. Takehiko Gonda analysed the pictures and supposed the shape of the snow crystal as Figure 3.

§ ACKNOWLEDGEMENT

The authors would like to express their sincere appreciaton to Mrs. Donna Miller, Mr. James Burrowman, Mr. Larry Thomas, Mr. Clake Prouty, Mr. Gary Walters. Mr. Dean Zimmerman and other NASA officers and engineers for their kind cooperation and encouragement.

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OVERVIEW

GETAWAY SPECIAL COMPETITION

CHRISTOPHER G. TRUMP

VICE PRESIDENT

SPAR AEROSPACE LIMITED

AUGUST 1984

Getaway Special Competition

On October 13 -- at a press conference in Ottawa -- Telesat Canada, The National Research Council and Spar Aerospace Limited -- announced a competition for all Canadians to think of something they would like to put into space. Spar, in our view, had the most exciting end of the competition, since we addressed ourselves to ordinary citizens to come up with an idea. We cared not whether it was handwritten or typed -- elaborate or simple. And we reaped the returns by the hundreds ...all based on the notion that experiments in space were not necessarily the domain of the experts and scientists in white coats.

From the 515 entries submitted to Spar -- 91 in French -- and all carefully review by Spar engineers and then screened by a blue ribbon panel -- we selected the nine finalists. As it was announced in the handsome brochure provided by Canada Post, the most important thing was the idea. Right along with this criterion was the quesion of do-ability -- or feasibility as the official word had it. The experiment had to be so constructed that it would survive up to eight weeks on the launch pad before liftoff. Finally, the experiment had to be affordable -- to be placed in a drum-size container weighing no more than 30 kilograms.

On that basis some finalists deserve special mention. They are:

Denis Carrier of Notre Dame du Nord in Quebec who submitted an experiment to verify the behavior of wooden particles in a magnetic field under conditions of weightlessness and a vacuum. However, the engineering problems in operating such an experiment in a canister without human intervention seemed formidable.

Guy Lambert, Michael Dennis and Normand Rondeau of Westmount, Quebec for testing the reaction in space of non-mixable liquids.

Gilles Primeau of Cookshire, Quebec for the imaginative construction of an entire satellite.

Brian Smith of Weston, Ontario to test the effects of weightlessness on sea urchin embryos. Since calcium growth (or loss) is a vital consideration in future, long-duration space flights, the experiment could have shed some light on how sea urchins develop their casing in space. The major problem proved to be insurmountable in the canister environment. How to change the water every other day?

Douglas de la Matter, Sheryl Boyle and John Kotash of the Madawaska Valley District High School in Barrie, Ontario, for determining the reaction in weightlessness of magnetized steel spheres.

Hugo Hohener of Elsa, Yukon Territory, to examine the effects of space on cancer cells.

Jessie Deslauriers of Kingston, Ontario to study the configuration of slime molds in weightlessness.

All of these experiments were imaginative, but posed special problems in terms of survivability or engineering. We were struck by the broad range of ideas: cockroaches, fruit flies, bread molds, fertilized eggs, silkworm cocoons, insulin, bacteria, cattle and chicken embryos, rat semen, wine, iron filings, bees and spiders spinning webs, to name but a few.

At the risk of being accused of unwarranted selectivity, let me cite just a few of the more imaginative ones that confronted the judges.

Four year old Matthew Lyons of Toronto for suggesting spiders in space.

Peter Pawlyschyn of Toronto for designing what has to be the first popcorn making machine in space.

David Brody of Port Hardy, British Columbia for sending in his five year old son's idea for seeing how a yo-yo would work in space.

Pauline Ebelshauser of Bramalea, Ontario for asking whether cockroaches would "still be pestering us in future colonies in space."

A registered nurse from Willowdale, Ontario, named B. Britz wonders whether your nose would still be able to smell "a rose, triffid or a roast beef out there in space" ...and wishes good luck out there in the final frontier.

Seven year old Benjamin Freeland from Sidney, British Columbia writes us simply in bold hand-writing, "I would like to send a duck into space to see how it flies with no gravity." Benjamin's dad writes that he is in Grade 2 of the French immersion program in North Saanich and that the program "has stimulated an interesting discussion here that I think will be of long term value even if Benjamin does not win".

Could there be a more resounding endorsement of this competition?

Nine year old Paul Dinga of Welland, Ontario asks that we put an iron net on the space arm to "catch a few meteors. See if there is life on them." He also provided a sketch of a habitat to "make space livable for people to live in like this picture."

Stanley Liu of Burlington, Ontario sends in an idea we will "probably think is crazy." It is for an entire house in space "with all the luxuries of home."

A.J. Maloney of Hamilton, Ontario asks in a poem "that we take along at least one empty container to fill up with refuse and garbage ...so you'll not litter space as you have the earth."

Jane Hill, age 11, of Scarborough writes that the "astronauts should try playing catch next year in the spacecraft ...P.S.: What is the prize and may I have a list of the winners? Thank you."

Winslow Clayborn of Montreal asks with the eloquent simplicity of a 10 year old: "I would like to see what happens to medicines ...will they last as long as they do on earth."

Helen Whelan, a housewife from Toronto, muses on what would happen to dishwashing in space ..."When I wash my dishes using liquid detergent, will bubbles form? What shape will they take ...I think it is time to research a few more domestic matters in space, apart from my wish to know about bubbles, that is."

Robin Sturdy of Crawford Bay, British Columbia, wants to build a ceramic kiln in space and measure the effects of space on the first ceramic tile made in space ...and adds: "Don't you guys forget my decal."

Then there was C.A. Simonsen of Alta, Alberta, who proposes sending the prime minister along for the ride.

Finally, the arts ...Martin Kramer of Toronto who wants to be the poet laureate of the Canadian space program.

Or Paul Hibbert of Nepean who wants to tell jokes in space -- "They should turn out to be funnier in space due to reduced gravity."

Now to the heart of the matter. The winners selected by a judging panel had ideas that were meritorious, eminently do-able and, in the view of those who are concerned with these matters, they were affordable. Coming from Nova Scotia, Quebec, Ontario, Alberta and British Columbia their suggestions, on handwritten notepaper or carefully typed entries, had one point in common: How would yeast react to the vacuum and weightlessness of space.

These were all solid experimenters -- no pie in the sky for them. Instead it was bread -- the first Canadian bread in space. After some consultation with researchers it was determined that the effects of space on yeast and enzymes has not been fully explored.

All of the finalists were guests of the Sheraton Centre for a two-night stay in Toronto, that included a meeting with U.S. astronaut Colonel John Fabian, who is in charge of the Canadarm and the Getaway Special Program. Canadian astronaut Dr. Roberta Bondar joined Fabian in the first public appearance of Canadian and U.S. astronauts together. With the assistance of experts in yeast experiments, Spar will develop an experiment to be placed aboard the shuttle late in 1985.

It has been an exciting competition which the Globe and Mail summed up best with their editorial on Leavening Space: Man may not live by bread alone, but a surprising number of Canadians have bread on their minds. When Spar Aerospace Limited invited suggestions for an experiment to be placed aboard the U.S. space shuttle next year, nine of 515 entries proposed sending up bread to see whether the yeast could survive in the cold weightlessness of space. And when the winning entry was announced at Toronto's Ontario Science Centre the other day, it was bread that carried the day.

ALEXANDER CURRAN is President and Chief Executive Officer of SED Systems in Saskatoon, a high technology systems engineering and production company. Before joining SED, Mr. Curran was Assistant Deputy Minister of the Space Program for the Department of Communications, and spent several years with Northern Telecom Canada Limited and Bell Northern Research. In addition to his professional accomplishments, Mr. Curran is a member of several national technology committees, and has authored more than 20 publications.

LYDIA DOTTO is a partner in Dotto and Schiff Science News Service, and co-director of Canadian Science News, a weekly syndication service. A freelance science writer since 1978, Ms Dotto specializes in computers, space, aviation, environment, ocean technology, and physiology. She has been the recipient of many science and journalism awards, including the Royal Canadian Institute Sir Sandford Fleming medal, and a National Newspaper Award, as well as honorable mention in the National Magazine Awards for 1978 through 1981.

GERALD FARNELL is Dean of the Faculty of Engineering at McGill University in Montréal, a position he has held since 1974. Dean Farnell joined this faculty in 1954 as an assistant professor, and has continued with the university in several positions, including Chairman of the Department of Electrical Engineering for seven years. He is the author of over 50 papers, is a member of several science and engineering committees, and has been the recipient of a Nuffield Fellowship, and an Institute of Electrical and Electronics Engineers Centennial medal.

KAREN GIRLING joined Spar Aerospace Limited in 1981 as Manager, Corporate Public Relations. Before assuming this position, she was with the Education Resources Division of the Addiction Research Foundation of Ontario. She is a member of the International Association of Business Communicators and the Canadian Public Relations Society, sitting on the program committee of the latter. Ms Girling has received numerous awards from technology and communication organizations including IABC and the Society for Technical Communications.

WALLACE IMMEN joined the staff of The Globe and Mail in 1972, and has worked at the science desk for the past three years. His most recent major stories include activities at the Ice Station CESAR, and two weeks at the Canadian High Arctic settlements, as well as extensive coverage of the United States space shuttle program. A member of the Canadian Science Writers' Association Executive Board since 1980, Mr. Immen is President for 1983-84.

JAY INGRAM has been the host of CBC Radio's science program Quirks and Quarks since 1979, which has garnered several national and international awards since his tenure. Mr. Ingram joined CBC as a freelance science journalist, after several years teaching chemistry and biology at Ryerson Polytechnical Institute and CJRT Radio's Open College program. His background and interest in science is extensive, but focuses on the history of science, evolutionary biology, and astronomy.

FRASER MUSTARD is the President of The Canadian Institute for Advanced Research. Dr. Mustard was with McMaster University for 16 years, holding the position of Chairman, Department of Pathology, Dean of the Faculty of Medicine, and Vice President of Health Sciences. He has participated on many committees and research organizations, including his present appointment as Director of the Ontario Heart Foundation. Dr. Mustard is a Fellow of the Royal College of Physicians of Canada and the Royal Society of Canada.

DAVID ONLEY is host of CKO Radio Network's SpaceWatch, a daily radio show profiling international activities in space. Mr. Onley is the author of Shuttle, which was nominated for Canadian Book of the Year in 1981. He is an active member of the Aviation-Space Writers Association, the Royal Canadian Air Force Association, and the Canadian Science Writers' Association.

WLADIMIR PASKIEVICI is the Director of Research for Ecole Polytechnique in Montreal. Dr. Paskievici has been with Ecole Polytechnique since 1958, holding both academic and administrative positions. He is a member of the Research Committee at the University of Montreal, and President of the Direction Committee of the Institute of Research in mineral exploration, as well as several science committees in the United States.

CHRISTOPHER TRUMP joined the Chairman's Office of Spar Aerospace Limited in 1982 after a 15-year career at Columbia University's Graduate School of Journalism, culminating as associate dean in charge of administration, student professional development, and external relations. Previous to Columbia, he operated as information director for NASA's New York-based Institute for Space Studies, and as lecturer for NASA's national educational programs. He is a member of the Canadian Science Writers' Association, serving as Membership Chairman for 1983-84.

TUZO WILSON has served as Director General for the Ontario Science Centre for 10 years, following almost three decades of teaching and administration at the University of Toronto. A member of several science committees, including the NATO Science Committee and the Science Council of Canada, Dr. Wilson is an Officer, Order of the British Empire, a Companion, Order of Canada, and the Chancellor of York University.

GETAWAY SPECIAL COMPETITION - FINALISTS - April 11, 1984

Annette Van Adrichem

New Lowell, Ontario

Annette Van Adrichem is a poultry farmer in New Lowell, approximately 90 miles north of Toronto. Married, with two children and expecting a third in October, Mrs. Van Adrichem claims that her Getaway Special idea was prompted by a home baking session.

With a background as a correctional officer, this versatile 28-year old also worked in the private sector before embarking on her new career in farming.

Mrs. Van Adrichem and her engineer husband returned from Winnipeg with their family last September to their poultry farm and have ordered 30,000 chickens to arrive in mid-April.

Annette's husband, John, also entered the competition. Both were somewhat disappointed that the Canada in Space decal sent to all contestants was not the iron-on variety.

Pam Cathcart

Greenwood, Nova Scotia

Pam Cathcart is an energetic 34 year old mother of two who supply teaches, is in charge of the maritime provinces' DES Action Canada group and has lived from coast to coast in Canada with her Canadian Forces husband.

Mrs. Cathcart's husband and a friend were discussing the Getaway Competition and asked her what she would send. "Bread," was her one word answer. Of course, she is quick to point out, it would have to be her own special multi-grain bread which she calls "everything but the kitchen sink."

Warren Chin

Toronto, Ontario

Warren Chin was born and lives in Toronto, where he is employed at the University of Toronto conducting scientific research in physiology, pathology and immunology. Dr. Chin returned from post doctoral work in Australia in October -- just in time to enter the Getaway Special Competition. He read about the Park Seed Company experiment that put seeds into space and adapted his idea as a further refinement.

Married, Dr. Chin is a sports and camping enthusiast, and at the moment is taking gourmet cooking classes.

Kathy Clayton

Calgary, Alberta

Kathy Clayton has lived all her 36 years in Calgary. This mother of two now works part-time in marketing research after a career with Environment Canada as a lab technologist in water analysis.

An avid stamp collector, Mrs. Clayton was visiting her post office when she saw the Getaway Special brochure. After testing a recipe at home she decided to submit her idea to the competition.

Mrs. Clayton claims that her family members are all space buffs. Her husband's position as a computer analyst and her part-time studies at the University of Athabasca have kept all of them well-informed on technological developments.

Jennifer Dufour

Richmond, British Columbia

Jennifer Dufour of Richmond, British Columbia credits her part-time employment with a western Canada grocery chain as the inspiration for her imaginative activities in the kitchen as well as her Getaway Special idea.

Married to a record salesman, this 30 year old mother of one is an arts and crafts enthusiast and is developing her interest in writing.

Eric and Isobel Lowden

Pincourt, Quebec

"We are essentially retired," says Eric Lowden as he shares credit with his wife Isobel for the inspiration for their Getaway Special entry. The Lowdens, both in their 60's and grandparents of eight, emigrated from Scotland to the Province of Quebec in 1955 and continue to pursue their many interests in Pincourt, near Montreal. She is the housepainter, gardener and oil painter, while he applies his background in electronics to his book and article writing. In fact, Mr. Lowden was mailing one of his manuscripts at his local post office when he saw the Getaway Special brochure which prompted the couple's entry.

Dorthy Munroe

Galiano, British Columbia

Dorothy Munroe lives on Galiano, a gulf island at the southern edge of British Columbia.

A native of Western Canada, Mrs. Munroe is a fifth generation Canadian who has lived in Vancouver as well as in Vernon, where she worked for 15 years in the surgical ward of a hospital.

Turning 64 in May, Mrs. Munroe took her first plane ride ever to be with us at this space night gala. An avid backyard astronomer, bird-watcher and theatre enthusiast, she also is a member of the Scottish country dancing group in Galiano, where the pace is a bit slower than in the city.

Mrs. Munroe says her inspiration for the Getaway Special competition came from her past experiences with food and beverage preparation.

William Pottie

Glendale, Nova Scotia

William Pottie's personal credo is "you're only as young as you feel." Mr. Pottie, 62, has just embarked on a three-month sea voyage to Algeria, which accounts for his absence this evening. For the last five years he has been employed as a chef with the Canadian offshore marines services. At home in Glendale, Nova Scotia, he pursues his favorite activities when not at sea: science and gardening.

Mr. Pottie's culinary skills, combined with his interest in science, helped him concoct his Getaway Special competition entry.

Annick Tremblay

La Plaine, Quebec

Twelve year old Annick Tremblay is the youngest finalist in Canada's first Getaway Special competition. She based her idea on knowledge gained in her sixth grade natural science classes. When not at school, Annick takes ballet/jazz classes and is an enthusiastic summer swimmer.

MODULAR AND STANDARDIZED GAS PAYLOAD HARDWARE

Guenter Schmitt
Kayser-Threde GmbH
Munich, FRG

Objectives:

Numerous payloads have been carried out within NASA's GAS program in the past and much more will be flown in the future. Therefore, besides the existing NASA GAS hardware, only modular and standardized payload hardware will lead to a reliable, cost efficient experimental platform with short turn around times.

Effort should be concentrated on science and experiments and not to much spend with standard service systems and related paperwork.

Payload requirements:

Common payload requirements within the GAS program can be summarized to

- economic use of available space and payload weight capacity
- adequate power sources
- variable payload timing and control including the GAS typical three on-off commands
- flexible housekeeping, data acquisition and recording systems
- standardized ground support equipment

All on board systems have to be capable to survive vibration and mission related temperature environment.

Standard payload service systems:

The design concepts for standard payload service systems are based on the common payload requirements.

Basically two different configurations of experiment/payload support structures are existing: one which uses round decks, hard mounted to struts (fig. 1), while rectangular shelves are attached to columns via shock absorbers with the other version (fig. 2). This design allows a more unique use of the GAS space and weight capacities, adequate inflight load carrying capability and a gentle environment for the deckmounted hardware.

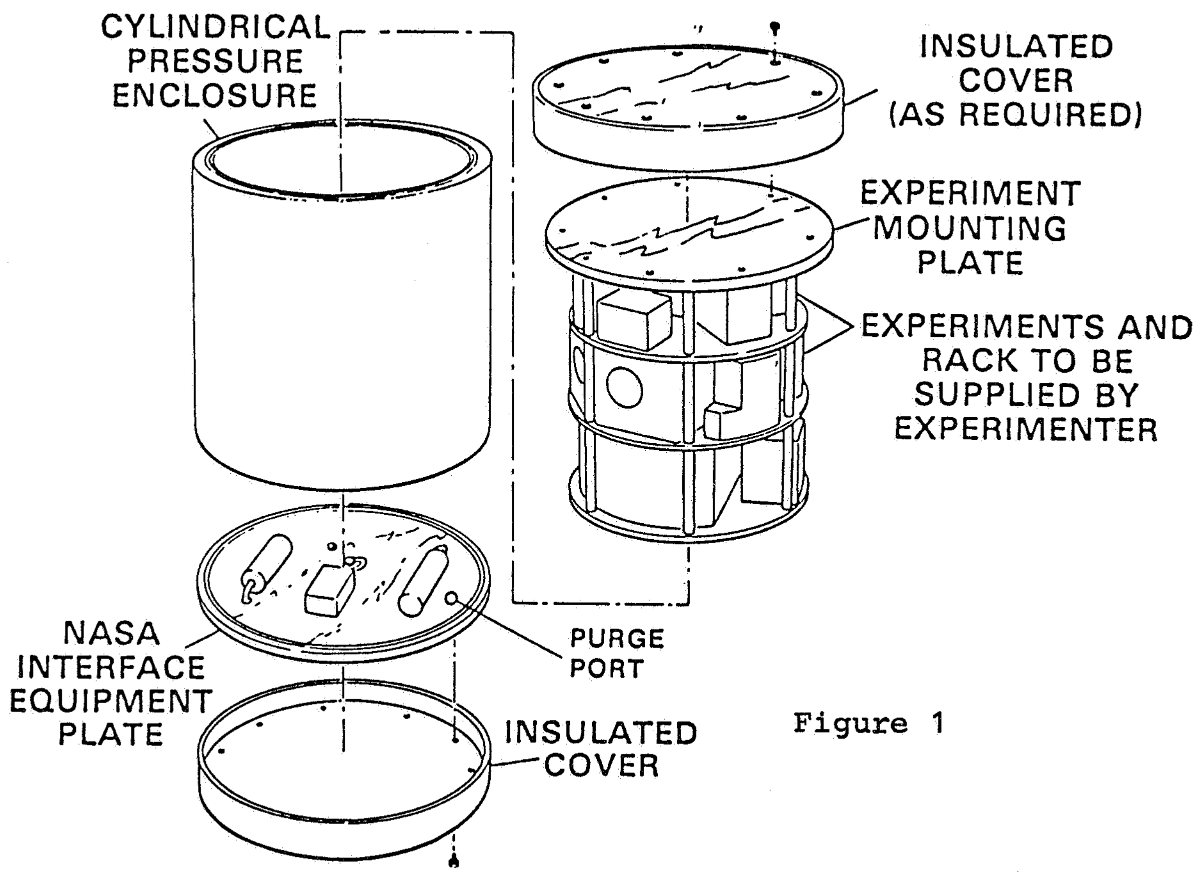


Figure 1

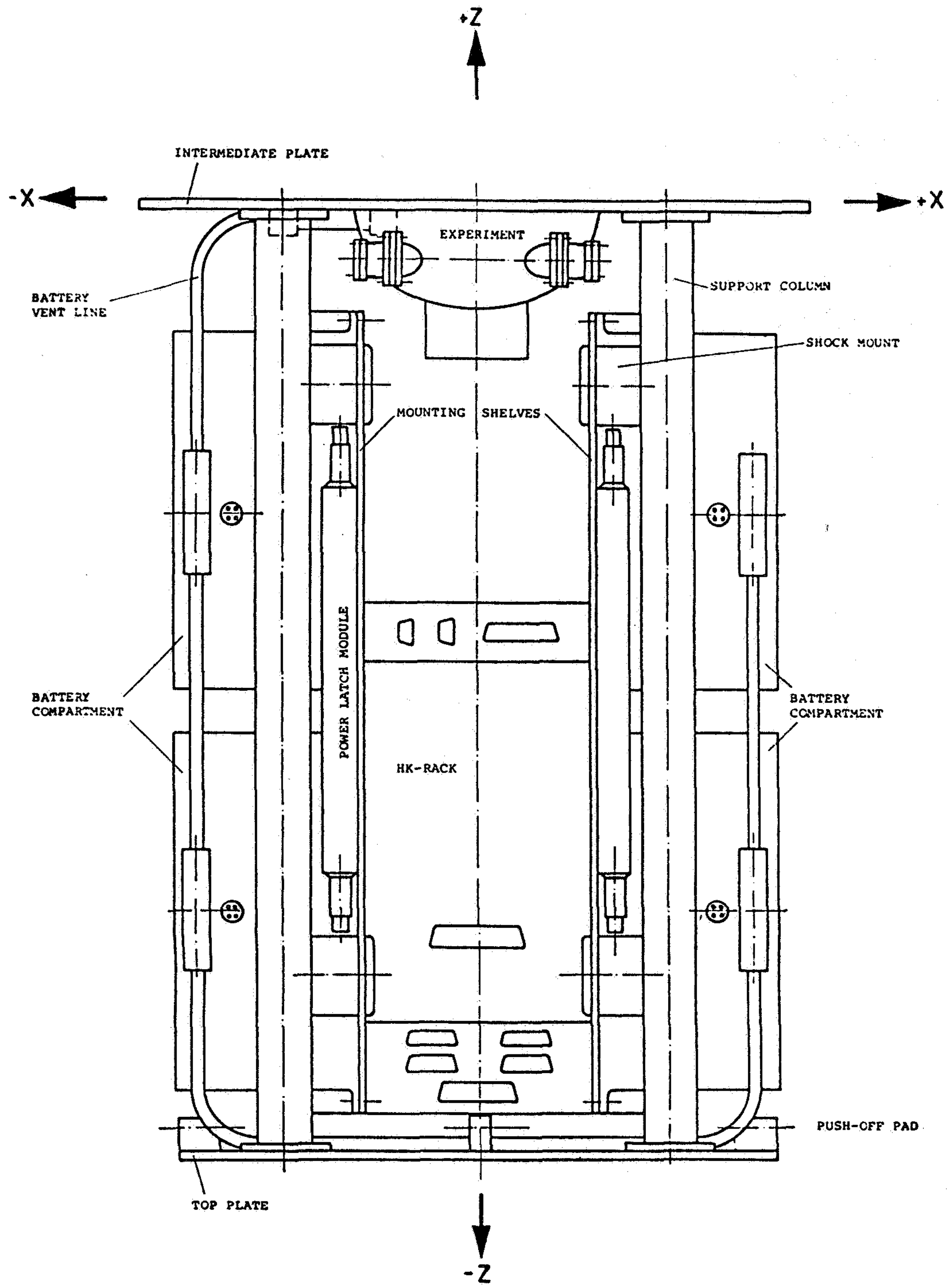

+Z
-X
+X
INTERMEDIATE PLATE
EXPERIMENT
BATTERY
VENT LINE
SUPPORT COLUMN
SHOCK MOUNT
MOUNTING SHELVES
POWER LATCH MODULE
HK-RACK
BATTERY
COMPARTMENT
BATTERY
COMPARTMENT
PUSH-OFF PAD
TOP PLATE
-Z

FIGURE 2

As power source silver zinc batteries were chosen presently representing the best compromise with respect to energy density, discharge characteristics, life time, self discharge rate, handling and safety. Some effort is involved with pressure tight and sealed battery boxes, the H_2 outgassing lines, temperature monitoring and fusing as well as the low voltage cut-off. Fusing and low voltage cut-off circuitry and the interface to the GAS PPC is integrated into the standardized power latch modules housed separately outside of the battery boxes.

To provide variable payload timing and control the three GAS typical on-off commands may not be sufficient for most applications. Therefore a microprocessor controlled and easily programmable sequencer with low power consumption (0,3 W) was designed. Redundancy is incorporated by using independend subroutines.

Experiment and housekeeping data are acquired at a data rate of 5 kbit/sec by a 16 channel, 12 bit PCM system.
The PCM system provides 12 analog and one digital channel for the experiments, while using two digital channels for housekeeping data and one additional for recording experiment time in minutes. All data are stored on a NAGRA cassette tape recorder with a total running time of approx. three hours and a storage capacity of approx. 56 Mbit. If operated in an intermittent mode, recording data for one second every minute covers a total payload operation time of approx. 120 hours.

During integration and ground tests the payload will be operated mostly by its ground support equipment which also allows recording and display of payload PCM data stream. The ground support equipment consists of standard power supply, battery simulator, NASA interface simulator, modular payload operation panel, display unit, PCM decoder and an Apple personal computer with dual floppy disk and monitor. All components are mounted in two portable racks. Last minute access to the payload is provided even if it is already installed into the flight canister. The payload can be completely operated via the NASA interface connector while status and data are monitored at the same time.

Standard experiment facilities:

Besides the payload service systems flight proven experiment facilities are available at Kayser Threde, too.

For fluid physics experiments a H_e-N_e laser Doppler interferometer with an optional splitted beam exists. The laser output power is 0,5 mW.

Optical observation can be done by a modified 24mm x 36mm photographic camera (Olympus) with a 250 picture film storage and a time display onto each picture by a LED array. Film cameras will be available at a later date.

For thermal processing of probes up to 500 ^{o}C an isothermal, multipurpose furnace can be provided. The chamber is 40 mm in diameter and 160 mm in length.

Plant development can be carried out in growth compartments furnished with temperature control, day/night simulation as well as liquid storage and injection devices.

Summary:

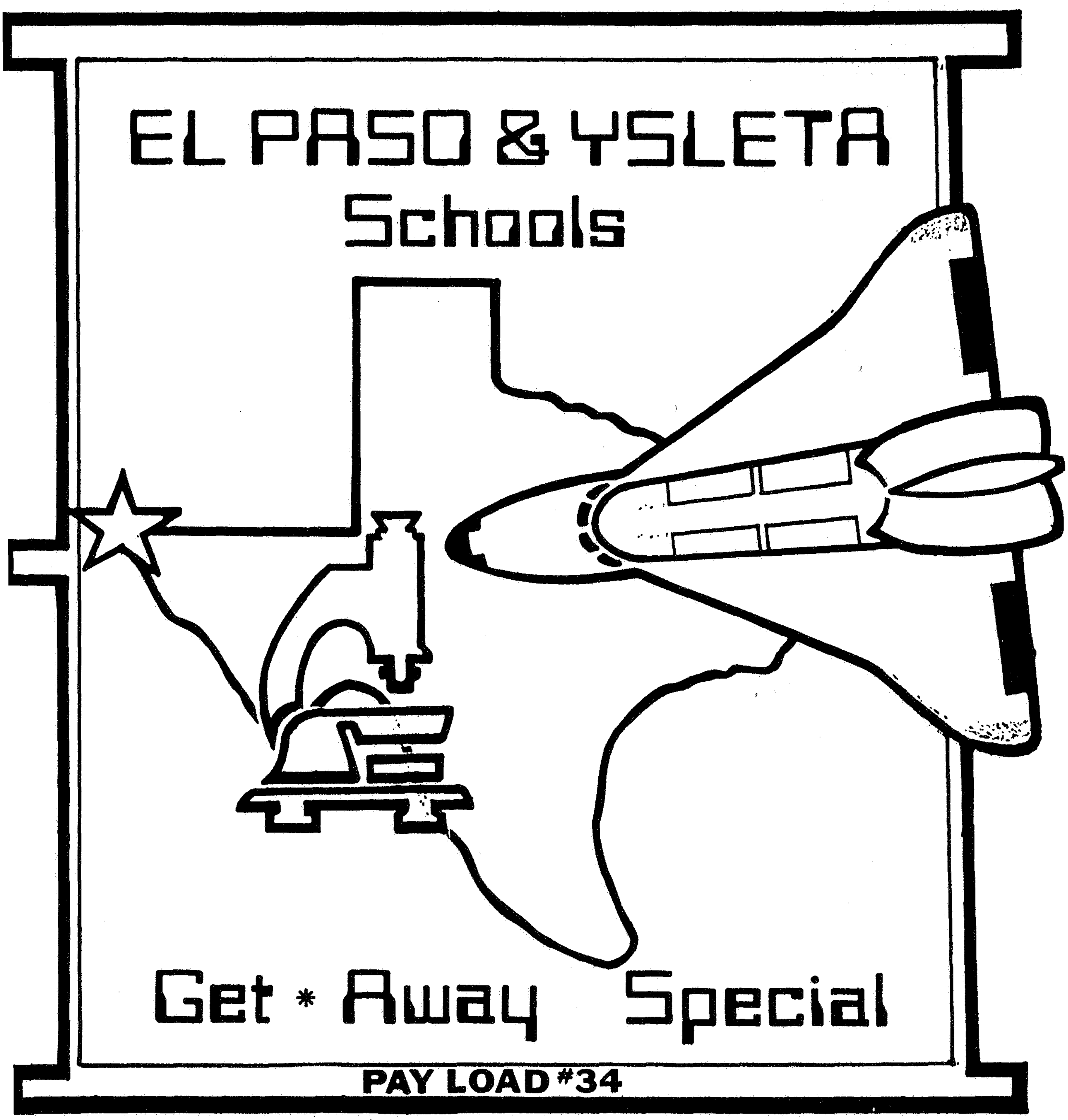
The use of modular and standardized GAS payload hardware has many advantages.

Standard hardware minimizes time effort and cost for design and qualification. Flight proven hardware ensures proper function and operation during mission. It demands less effort with respect to the preparation of the payload accommodation requirements and the safety review data packages for the user as well as for NASA.

Modular systems allow to be combined in order to serve an enlarged number of experiments if two GAS canisters are interconnected.

These facts enable the user or experimenter to concentrate on the experiments and related science instead of spending time in development of own hardware while standard, flight proven systems are available.

Nevertheless, cost efficiency for standard service systems encreases by each reflight.


EL PASO & YSLETA
Schools
Get * Away Special
PAY LOAD #34

Mr. Richard N. Azar, through reserving three Get Away Special (GAS) containers, began the GAS program for El Paso, Texas. "Space is a challenge, always has been," Azar said. "The canisters offered us an opportunity to challenge young minds."

Azar got the idea for participation in the space shuttle program in 1977 when he read a magazine article about the National Aeronautics and Space Administration's offer to let private individuals send experimental projects into space aboard what was then called the "space truck" Columbia.

Azar contacted NASA and made a down payment of $500 each for three canisters. Each capsule has a price tag of $10,000.

One canister was set aside for the twin cities of El Paso and Juarez, another for the University of Texas at El Paso and the third was designated for projects developed by high school students.

The El Paso containers are numbered 33, 34, and 35, and are grouped under the Education queue. El Paso Independent School District and the Ysleta Independent School District have deposited the necessary $9,500 with the El Paso Community Foundation to complete the funding for payload #34.

The El Paso/Juarez Space Shuttle efforts began in late 1977 to provide research opportunities and interesting space related activities for the El Paso Area school systems. In the Fall of 1982 more than 100 students in the local school districts participated in an advanced science seminar giving background on the project. Any student interested in the study of space and space activities was invited to prepare research and prepare an experiment in his or her field of interest. Twelve students from the El Paso area have developed scientifically worthwhile projects. These students will have the opportunity to send their experiments on board the NASA Space Shuttle in August of 1984.

This experimental opportunity for students is an effort to motivate those interested to reach new horizons through space research. Through planned activities, trips, contests, seminars, and speaker programs, thousands of El Paso students have become aware of what the future holds in space. They, too, have contributed valuable insight and questions to be asked. Expanding young minds is the greatest resource for mankind.

This GAS payload consists of an Aluminum 6061 frame, with four shelves supporting the experiment hardware, the system controller and power supply. This frame was designed developed and tested by Farah Manufacturing and El Paso Natural Gas of El Paso. The experiment hardware is machined out of plexiglass. Engineers Vernon Strickland and Mike Izquierdo assisted students with design plans. The containers were built to specifications by Whaller Specialties and Falco Machine & Tool Company. The power supply for the payload consists of Gates lead-acid batteries with a power life of 45 hours at 1 amp/12 volts DC. The power supply will be used to operate linear actuators, light emitting diodes, thin film heaters and other electronic devices in the payload. The cost of the batteries was underwritten by El Paso Electric Company.

This particular GAS payload is unique in regard to the planned operational scenario. Experiment 7-P(the Fuel Wicking Experiment) is designed to measure the wicking of a simulated fuel on a thin wire screen during acceleration. Its operational period is from SSME ignition through the OMS-1 burn. Experiment 7-P will have a self-contained power supply and controller separate from the main payload controller and power supply. It will be activated by the noise of the shuttle liftoff and, through a timer, shut itself down upon completion of the OMS-1 burn.

The container will be purged with dry nitrogen prior to installation in the Orbiter. An insulated cover will be installed over the container experiment mounting plate exterior. No unique flight design requirements are requested for orbit altitude, inclination, or orientation and stabilization. The assignment of GAS Control Decoder (GCD) relay states to specific payload functions is shows in Table 3.2.2-1. The required payload crew activities during the flight are shown in Table 3.2.2-2.

EL PASO/YSLETA SCHOOLS GET-AWAY SPECIAL
SPACE SHUTTLE STUDENT PROJECTS

2.0.1 DAVID BOWDEN - EXP. 1-B - GROWTH OF LETTUCE SEEDS

PURPOSE: The purpose of this project is to see how the Lactuca Sativa (lettuce) seed will germinate and grow in a weightless environment. This project will also answer many questions such as: what the health of the plants will be, the biomass of plants grown in microgravity, and the formation of new root structures in microgravity.

PROCEDURE: The experiment hardware is a self-contained and fully automated growth chamber providing all the required factors for proper germination. It provides a terrarium environment (on a small scale) with pilot light, to one chamber level, temperature control and thermal insulation. The project also preserves all specimens for further ground based testing.

This experiment is designed to run 112 hours. The first function, after activation, will involve pumping growth solution into the various chambers. The second pumping will occur at 72 hours. The final pumping will be the fixative into the chambers. The lighting cycle will be 10 minutes of light every hour.

2.0.2 GISELE BRYANT - EXP. 2-B - SEED GERMINATION

PURPOSE: This experiment will observe genetic changes in barley seeds germinated in microgravity. Further, the experimenter plans to determine if these seeds will have genetic changes in future generations.

PROCEDURE: Place 100 raw seeds in the container. Bring the temperature to $20^{o}C$ +/- $5^{o}C$. Inject approximately 40 cc of hydroponic H_2O. Turn LEDs on 72 hours after H_2O is injected in intervals of 10 minutes every hour. Inject final 15 cc. hydroponic H_2O into chamber prior to termination.

2.0.3 DONALD R. CAKE - EXP. 3-B - GROWTH OF BRINE SHRIMP

PURPOSE: The goal of the experiment is to study the growth rate of brine shrimp and morphological development during the hatching of brine shrimp eggs over a 72-hour period. The data from this experiment will add information to an organism that has already received a great deal of study.

PROCEDURE: Brine Shrimp will be injected at 0 hours, 24 hours, 48 hours, and 60 hours into the hatching chamber of the canister. At T=112 hours, during deactivation, a fixative will be injected into the chamber.

2.0.4 PRISCILLO CAMPOS - EXP. 4-B - GERMINATION OF TURNIP SEEDS

PURPOSE: The goal of this experiment is two-fold. The first is to collect statistical data on the germination rate of turnip seeds in microgravity. The second goal is to conduct a post-flight analysis of the plant biomass and cellular structure. Since plants are being considered for use in the Close Life Support System, this data could provide useful information on what types of plants are best suited for such a system.

PROCEDURE: The turnip seeds will grow in space for approximately five days and then be preserved for examination. The container will be kept at a constant temperature of 70°F (20°C). The container also has linear actuators to inject water or preservative onto the seedbed automatically.

The container is made of clear plexiglass . It is secured by four bolts with nuts, washers, and split washers. The container has three main sections and it will be divisible for easy classification. The first section is the experiment electronics, the linear actuators. One of the actuators will inject water while the second injects preservative onto the seeds. The second level is the liquids container measuring 5" x 5" x 3". It has two holes bored into it, and each one has a plunger which will individually push water and formalin. The third level is the seedbed which measures 5" x 5" x 1" and has a 4" diameter circle bored into it. There 200 seeds will be placed with about eight layers of paper towels, four above and four below the seeds.

At T=1, the linear actuators will inject 15cc of water into the seed chamber. After the water has been injected, the plunger will be raised to release air pressure. At the same time, the heaters will keep a stable temperature inside the seed chamber. The seeds will continue to germinate for about five days. The heaters will be turned on and off during the five days as well. At T=112, another linear actuator will inject 10 cc of formalin into the seed chamber. The seeds will be preserved to prevent the turnip seeds from decaying. Data will be recorded to determine how many of the seeds have germinated and the structure of the plants.

2.0.5 CLAY CASAREZ - EXP. 5-P - LIQUID LASER

PURPOSE: The laser has many physical uses in space, and this experiment will evaluate the changes in the effectiveness of a Dye Laser in a zero gravity environment.

PROCEDURE: Bring the temperature up to 0°C and maintain at 0°C+. Then follow procedures on flow chart for liquid laser project.

2.0.6 MONICA CHAVEZ - EXP. 6-B - PLANARIA REGENERATION

PURPOSE: The planaria regeneration objective is to observe the effect of microgravity on cell regeneration. Further, this project will determine if regeneration will be altered by either being accelerated or decelerated. In the near future, surgery will be performed in outer space; with this cell regeneration information available, potential hazards or benefits can be anticipated in the healing process.

PROCEDURE: This experiment will send 15 Planaria Dugesia Tigrina (brown planaria) into the growth chamber of the experiment. They will be kept alive by the circulation of the liquid medium both prior to flight and through five days of the mission. Prior to deactivation, a fixative will be diffused throughout the solution in order to preserve the Planaria. The fixative will enable the observation of their survival.

2.0.7 KELLY FOSTER - EXP. 7-P - WICKING EXPERIMENT

PURPOSE: This project is designed to collect data on the accumulation of fluid on a metallic screen due to wicking. This information will help evaluate the fuel recovery efficiency of the Space Shuttle fuel cells.

PROCEDURE: A small sample of the fuel screen used in the fuel system of the space shuttle, to transport fuel from the storage tanks to the combustion section, is used in this experiment. The screen is placed in between two single sided pieces of copper clad material creating a capacitor. The dielectric of the capacitor consists of the screen and the fluid. In this case freon 113 represents the fuel, which will wick on the screen. The increasing and decreasing of the fluid on the screen will cause the capacitance of the capacitor to change. The changing capacitance will be digitized and stored in two 2k EEPROMs.

The experiment will be turned on by the noise generated by the engines at liftoff. The noise will be converted to electrical energy by a piezo crystal, which turns on a transistor, which picks up a relay, which puts power on the experiment.

Power will remain on the experiment for approximately 15 minutes. This is accomplished through a timing circuit which will remove power after approximately 15 minutes. Power is fed through a magnetic latching relay which is controlled by GCD relay B. When GCD relay B is in the "latent" position, power is fed through the magnetic latching relay to the experiment. When GCD relay B is made "hot", the power is removed from the experiment and remains removed even when GCD relay B goes back to the "latent" position.

2.0.8 KAREN HERMAN - EXP. 8-B - EFFECTIVENESS OF ANTIBIOTICS ON BACTERIA

PURPOSE: This experiment will determine the effectiveness of antibiotics on bacteria in microgravity as compared with that action on earth. The data will be obtained on a photographic plate being exposed through the plexiglass container by LEDs. The significance of this experiment will be to provide data to future human space colonies, as to the use and effectiveness of antibiotics to treat bacterial diseases.

PROCEDURE: Once in orbit, the heater will be turned on to heat the container to 37°C. Then a linear actuator will push down the plunger of the syringe and puncture a membrane. This allows the lyophilized bacteria to become active by being mixed with nutrient broth. It will be in this state in the syringe for 6 hours. Then the linear actuator once again pushes the plunger and punctures another membrane so that the mixture of the bacteria and broth are sprayed out onto a surface of agar in the growth chamber. Two minutes later two antibiotic discs will be lowered and placed onto the surface of the agar by the linear actuator. After 20 hours have passed, a picture will be taken from the bottom of the container using a photographic plate and two yellow LEDs. On the completion of the photograph everything will be turned off, including the heat.

2.0.9 REBECCA LOPEZ - EXP. 9-B - OBSERVING GROWTH OF SOIL MOLD

PURPOSE: This experiment will examine the growth patterns of the mold Mucor rouxii under anaerobic and aerobic conditions while exposed to microgravity. The growth of the mold is affected by the environmental culturing conditions. In an aerobic environment M. rouxii closely resembles the morphology of common bread mold. Sporangium is produced with spores and rhizoids. Under anaerobic conditions the M. rouxii morphology is similar to that of yeast. The data from this project may gleen new knowledge about the life cycle of M. rouxii. It would be useful since M. rouxii can cause severe crop damage.

PROCEDURE: Both of the containers that will be used for this experiment will be made out of plexiglass, sealed with RTV sealant, and bolted together with one quarter inch stainless steel all-thread bolts. Before this experiment is placed in the canister 75 millimeters of agar medium will be poured into each of the plexiglass containers, and the atmosphere of one of the containers will be changed to the anaerobic condition with carbon dioxide and nitrogen gases. The following steps will be the time line for this experiment: At T=1 the two heaters will bring the temperature to 28°C plus 5° or minus 3° and this temperature will be maintained throughout this experiment. Then the #1 linear actuator will be turned on, driving syringes A and B to each inject 20 microliters of Mucor rouxii spore into the growth chambers. After 35 1/2 hours have elapsed, the two yellow LED lights will be activated for 40 seconds. This will take photographs of the growth structure of the Mucor rouxii culture before injecting the preservative. After 10 minutes have elapsed, #2 linear actuator will be turned on, driving syringes C and D to each inject 3 cc of Formalin preservative on one side of the agar medium. Finally, the experiment can be turned off.

2.0.10 JAMES MARTINEZ - EXP. 10-B - POST FLIGHT EXAMINATION OF PLANT GENETIC STRUCTURE

(Will not participate in flight operations)

2.0.11 MICHAEL MOORE - EXP. 11-B - CRYSTALLIZATION IN ZERO G

PURPOSE: This experiment is to test for similarities or changes between crystals of Potassium Aluminum Sulfate grown in zero gravity and those grown on earth. The crystals grown aboard the shuttle will be compared to a like set of crystals grown under the same conditions in El Paso. Several tests which are standard to crystal testing will be used. It is expected that better, or even close-to-perfect, crystals will be grown. They will probably be much clearer and may possibly have a different shape than those grown on earth.

PROCEDURE: The solution, H_20 and Alum, will be prepared in El Paso. It will immediately be placed in the growth chamber in the structure and the latter will be sealed and ready for shipment. When the experiment is turned on, a linear actuator will push a plunger down a small shaft, thus relieving the negative pressure within the growth chamber. The crystals should then begin to grow. At this time the experiment will be finished and ready for testing. (During all of this, the temperature will be maintained above zero degrees Celsius.) The time duration for the linear actuator to move the plunger will be one minute.

2.0.12 - RUDY SANTINI - EXP. 12-B - SYMBIOTIC GROWTH OF CHLORELLA AND KEFIR IN MICROGRAVITY

PURPOSE: The goal of this experiment is to establish a symbiotic life support system in microgravity and monitor the growth rate of the two biological organisms. Kefir, a composite lactose fermenting yeast, will provide the carbon source. Chlorella, a unicellular green algae, will use the carbon dioxide provided by the Kefir, and in turn produce oxygen. In effect, a closed eco-system will be established. Closed loop life support systems, containing biological organisms have been proposed for use in space stations and manned interplanetary space craft. The data from this experiment would be a first step in understanding the operational dynamics of such a system in space.

PROCEDURE: When the power is turned on, the heater will be activated to maintain the container within the temperature range of 20°-$25^{\circ}C$. Then the linear actuator will move a blade forward (3/16 inch) breaking the membrane which is holding back the nutrients from the Chlorella and Kefir. After the membrane is punctured, the linear actuator will pull the blade back 3/16 inch. After 112 hours growth time, the linear actuator will pull full back and act as a suction cup pulling the preservative into the chamber. After five minutes have elapsed, all of the power will be turned off.

2.0.13 JOHN THURSTON - EXP. 13-P - DRAM CHIPS

PURPOSE: This project is designed to find out if the conditions of space such as cosmic rays and weightlessness affect the performance of computer chips. This will be accomplished by testing computer memory chips on the ground and in space. Both Japanese and American chips will be used to see if there is any difference in their performance. After the flight, the results obtained in space will be compared to the results previously obtained on the ground and any differences analyzed.

PROCEDURE: Dynamic Random Access Memory (DRAM) chips will be used. The DRAMs consist of thousands of transistors in which the gates can be charged to a certain voltage level. Because the charge on the gates leaks away slowly the charges have to be read and restored to their proper level periodically. This process is known as refresh. If refresh is not done within a certain time limit, the charge in the gates will have leaked away and any data stored in the chips will be lost.

Testing of the DRAMs will be done by using a microprocessor to write a test pattern to the chips and then count any errors that occur. A 2K EEPROM will be used to record the number of errors that occur. This testing will be done with different amounts of time between refresh cycles to determine how fast the charge is leaking away from the gates.

Clay Casarez- 9B
Project: Testing a liquid Laser

The problem to be studied is the construction of a liquid laser capable of comparing the behavior of a liquid laser on earth and one in space regarding:

a) the temperature of the laser unit - liquid laser and space surrounding the light pump area;
b) the condition of the generated beam in respect to color, intensity, and distortion;
c) the relative power output of the laser under both conditions.

The proposed experiment is to be limited to the use of a liquid laser only in order to observe how the liquid will react in the near zero gravity of space as opposed to the earth's gravity.

Laser stands for Light Amplification by Stimulated Emission of Radiation. There are four kinds of lasers. These are: solid, liquid, gas, and semi-conductor.

The solid laser consists of: a) a rod of aluminum oxide with small amounts of impurities such as chronium; b) a light source suspended around the laser rod consisting of xenon flash tubes or similar light intensity (the light tube being either linear or spiral); c) one fully reflective mirror and one semi-reflective mirror system placed at opposite ends of the laser rod, as shown in Figure 1.[1]

The lasing action occurs when the light source pumps or excites the chronium electrons causing the electrons to "jump" into a higher orbit. The chromium electrons then tend to return into their normal orbit and is so doing, liberate energy in the form of light. The light particles are then reflected back and forth between the mirrors until the beam becomes strong enough to pass through the semi-reflective mirror in a coherent beam.

The liquid of dye laser works on the same principle as the solid laser except the medium is pushed through the optical cavity by means of a mechanical liquid pump system. Tuning of the Coherent beam is accomplished by the use of a prism or a defraction grating[2] isolating only the part of the spectrum to be studied, as shown in Figure 2.[3]

The gas laser's operation consists of:

a gas discharge tube that is highly evacuated and then filled with gas, placed between two mirrors forming a resonant optical cavity. When the gas is excited via an external energy source such as a current discharge, photons are produced and due to the amplifying action of the cavity and mirrors, laser radiation is produced.[4]

GET AWAY SPECIAL SYMPOSIUM
AUGUST 1-2, 1984
GODDARD SPACE FLIGHT CENTER
GAS 007
MARSHALL AMATEUR RADIO CLUB EXPERIMENT (MARCE)

Edward F. Stluka, W4QAU
MARCE Principal Investigator

INTRODUCTION

The Marshall Amateur Radio Club Experiment (MARCE), started in 1978, was designed, assembled and tested by the Marshall Space Flight Center Amateur Radio Club (MARC), in Huntsville, Alabama, for supporting the Space Shuttle Get Away Special (GAS), #007 student science experimenters. The Project Explorer, GAS #007 is planned to be launched October 2, 1984, on STS-17 (41G) and is sponsored by the Alabama Space and Rocket Center, Huntsville, who paid the fee, and the Alabama Section of the Institute of Aeronautics and Astronautics (AIAA). The AIAA, with four universities, University of Alabama, Huntsville and Tuscaloosa, the University of Auburn and the Alabama A&M University, selected the student experiment proposals. The MARC was requested to provide a radio experiment when no radio experiment proposal was submitted.

In addition to supporting the student experimenters, the objectives of the MARCE are:

(1) Demonstrate amateur radio data communication from the cargo bay, during a Space Shuttle mission, on a non-interference basis with the Orbiter and its payloads.

(2) Involve educational groups of all ages to emphasize space communication opportunities for like type ventures of volunteer research and creativity.

(3) Encourage broader participation of amateur radio enthusiasts in this space research adventure capitalizing on the pioneering spirit of volunteer amateur radio operators and shortwave listeners around the world.

Design Considerations

1. Integration - As a guest experimenter, the MARC was requested to perform the GAS payload integration task. In addition to providing the primary power, control and distribution networks to electrically integrate the experiments, an instrumentation measuring system, a data system and an RF downlink system were designed.

2. Measurement and Instrumentation - Figure 1 is a review of the MARCE. The measurement inputs were first requested from the student experimenters in 1978 in an attempt to size the design required by the MARCE. Figure 2 shows the voice message formats and calibration data curves for the measurement list in Figure 1 and the GAS #007 health status. The instrumentation conditions the measurement sensors for inputs to the Analog to Digital Converters (ADC). The Digitalker* system changes the ADC signals to voice (English).

The Digitalker* was chosen to appeal to the widest possible segment of the amateur radio community as well as shortwave listeners. The downlinked message output from a 435.033 FM receiver can be recorded on a cassette during an Orbiter pass. During playback, the listener can, by using the data curves, status code and mission timeline, get a firsthand, real time experimentation progress report. Receiving a copy of the cassette at MARC from the ground stations around the world is vital to reconstructing the health of the experiments in flight. Relay of the data by amateur radio would greatly expedite the data flow.

In the event that the Orbiter's cargo bay is facing space during an RF transmission and the OSCAR AO-10 satellite can relay the MARCE data, the 2 meter receiver or scanner set at 145.9720 MHz could possibly receive the data, depending on the AO-10 location, receiver sensitivity, antenna gain and other RF link parameters.

3. Power and Control - The power, control and distribution system likewise was designed with the experimenters' inputs. Tradeoffs were continually required between student requirements and limited power and control methods. The more significant trades are:

a. It was found that one central power source was more efficient than separate experiment power sources. With multiple power sources, long duration relay (300 ohm) loads would consume significant power. The CPU completes the ground circuit of the control relays in accordance with timed sequence. Experiment 3 is the exception. It carries its own flash batteries, however, the 1.5V precision reference voltage provides a continuous power source for the 24-hour crystal growth experiment.

b. Continuous RF transmission would consume enormous power (75 ampere hours), therefore, three 8-hour downlinks were chosen (7 ampere hours). The RF transmission in each 8-hour period is made at the start of 4 minute segments and lasts long enough to transmit the data message. The first 8-hour period starts with GAS 007 initial "Power ON." Each data message (Format A) lasts less than 30 seconds. This data provides knowledge of the

*Trademark

payload health and monitors Experiment #2 heater operation and, at 00400 hours (4 hours after GAS #007 "Power ON), Pump A operation flows nutrient to the radish seeds. The second and third 8-hour downlinks provide Experiments 1 and 3 operational data and lasts about 45 seconds (Format B) every 4 minutes. See Figure 3 for power profile and mission timeline.

c. Continuous operation of I1, the current sensor, likewise would consume significant power (6 ampere hours). Therefore, I1 is turned "ON" for one second every ten minutes, except during the downlinks when it is turned on for ten seconds at the start of each radio transmission. The solid state sensor requires 50 ma.

d. The use of CMOS devices conserves power and allows non-volatile memory by use of alkaline "D" size batteries. The memory will store all MARCE data every ten minutes throughout the 120-hour mission. A less than one microampere drain over the period of several months should assure post-flight data retrieval.

4. Special Problems

a. RF transmission from the GAS container takes the lead in the problems encountered. The most difficult was the approval for lid modification to accommodate the RF coaxial cable feed through connector and approval for RF transmission from the cargo bay.

To date, approval for RF transmission has not been received. The complexity of the STS-17 payload manifest indicates that another flight should be selected; however, there are no other flights with 57^{o} inclination until mid-1986 when a greater than 95^{o} inclination is scheduled for OASTA-5.

Other problems include three notifications to the FCC, 27 months, 15 months and 3 months prior to space operations; RFI, EMI, antenna pattern and other tests required to assure compliance with FCC regulations as well as proper operation in the cargo bay, and to assure non-interference with the Orbiter or the payloads.

b. The lack of STS-17 timelines or Crew Activity Plan (CAP), forced MARCE to generate and use a simulated timeline for simulated flight test, thermal tests and other planning. GAS #007 experiments 1 and 3 desire to operate and MARCE desires to transmit during crew sleep periods and the other STS-17 payload down times. During this time, the lowest "G" levels are expected and the potential for interference, at transmitter full power (approximately 4.5 watts), to the STS-17 payloads is reduced or eliminated.

c. The RF transmitter power level is dependent on the location of the nearest payload component/assembly that is susceptible to RF interference. The SIR-B electronics enclosure is located about 1.6 meters from the GAS #007 container. If there is a possibility that MARCE RF transmissions would occur during the SIR-B radar "ON" times, then the MARCE transmitter RF power would be limited to 0.5 watts.

d. The 23 cell silver zinc battery requires special attention that dry cells do not. Safety requires (1) redundant vent lines from the battery case to the GAS lid relief valve assembly; (2) safety requires absorbent material above the cells to absorb possible electrolyte (KOH) leakage, and Solethane 113 chips placed between the absorbent material and the battery top cover, to displace any H2 expelled by the cells, when the GAS #007 experiments take energy out of the battery; and (3) safety requires a fail safe thermal control circuit that will turn GAS #007 power "OFF" when the battery case temperature reaches about $75^{\circ}C$. Such a high temperature would indicate a critical cell(s) short and/or reversal. This is a most serious safety critical condition because of the potential consequences.

5. Volunteers

MARCE could not have been completed without the help of the many who responded to the request to work on MARCE. The major volunteers are noted here: Data System and Software - Chris Rupp, W4HIY. Antenna - Reggie Inman, design of antenna and lid feed through. Ed Martin helped Reggie with antenna evaluation tests, radiation patterns and balun tuning. Power, Control, Distribution, Instrumentation - Art Davis, WB4KKA. RF System - Leon Bell, WB4LTT, evaluated the transmitter, prepared the RF system test plan, performed the RF link analysis, conducted EMI tests, transmitter stability, transmission line design and VSWR measurements. Fabrication and Planning - Bill Richardson, W4LRE - mechanical, milling, fabrication work on the antenna and electronic support assembly. Battery - Al Henry activated, load tested and coordinated with KSC for flight battery activation at KSC and with GSFC for battery flightworthiness preparations. Flight and Ground Operations - Leigh DuPre, WB4WCX, Ed Clark, K4KFH and Joe Appling, W4WIA - MARC station readiness, OSCAR relay and amateur radio community coordination. Mechanical Design - Ken Anthony and Jerry Hudgins. Stress - Tom Stinson. Assembly and Systems Test - Guy Smith, Chris Rupp, Leon Bell, Leigh DuPre. Payload Inspection, Quality and Documentation Compliance - Wiley Bunn, NO4S.

6. Contributors

MARCE could not have been completed without the companies and individuals contributing hardware and effort. Motorola - Jim Worsham, WA4KXY and the Fort Lauderdale, Florida, Motorola Portable Products Division provided the modified 5-watt transmitter and the handheld receiver (GSE). Zero Corporation - Jay Shorette and the Zero Corporation provided the MARCE electronic support assembly enclosure which houses the MARCE data system, signal conditioning, power distribution and experiment control, and I1, the current sensor. National Semiconductor Corporation - Peter Lami and the Interep Association, Huntsville, Alabama, provided two sets of the CMOS modules for the MARCE data system, one set for the prototype, the other set for the flight unit. RCA - Ivars Lauzuma and the Somerville, New Jersey, RCA Solid State Microsystems facility provided an 1802 CPU data system, A/D converter and related parts. The University of Alabama, Huntsville - The University's Environmental Lab provided space for assembling and testing the GAS #007 package. The UAH machine shop provided the major portion of the GAS #007 structural fabrication, drilling, machining and final fitting work. Space Processing Applications Rocket Project (SPAR) - 28V DC, 20 ampere hour batteries, 7.5V DC regulator, instrumentation sensors, connectors, and related parts were obtained from surplus hardware. Midwest Components, Inc. - John Saling and MCI provided the thermal sensing switches for the battery.

Consultation

The following organizations-persons provided guidance, recommendations and encouragement:

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Kennedy Space Center (KSC)
J. D. Collner, W4GNC, KSC technical representative for MARCE Eric E. Olseen, Andy Wheeler, WB4ZLW.

Jet Propulsion Laboratory (JPL)
Jim Lumsden, WA6MYJ, JPL technical representative for MARCE.

GAS 007 POWER USAGE

0243-84

RADIO DOWNLINKS 1	RADIO DOWNLINKS 2	RADIO DOWNLINKS 3	OTHER	PULSING LOADS	RELAY GCD	GAS 007 RELAY
8 HRS				(2) TX 30 SEC/4 MIN .593 A (INCL K4 AT .093A)	AB, C	K4
30 SEC				(3) EXP 2 PUMP 1 - 120A (PUMP) + .093A (K1) = .213	A	K1
		15 MIN		(5) EXP 1 OVEN 1, 1.75 AMPS	A, C	K2
		*30 MIN		(6) EXP 1 OVEN 1, 1.75 FOLLOWS (5)*	A	K2
		6 HRS		(7) EXP 1 OVEN 1 DATA SYS .250A A+.093A K2=.344A	A	K2
	20 MIN			[5] EXP 1 OVEN 2, 2.0 AMPS	A	K2
	*30 MIN			[6] EXP 1 OVEN 2, 2.0A FOLLOWS [5]*	A	K2
	6 HRS			[7] EXP 1 OVEN 2 .250 A DATA SYS + .093A K2=.344A	A	K2
			(1)	(9) CURRENT SENSOR (CSI) .050 A 1 SEC/10 MIN	A	–
8 HRS	8 HRS	8 HRS		(10) CURRENT SENSOR (CSI) .050 A 10 SEC/4 MIN	A	–
	8 HRS	8 HRS		(11) TX 45 SEC/4 MIN .593 A	A,B,C	K4
			(2)	(12) EXP 2 PUMP 2, 30 SEC .120A + .093A (K5)	A	K5
				CONSTANT LOADS		
X	X	X	120 HRS	(1) EXP 4 DATA SYS .036A 120 HRS	A	–
X	X	X	120 HRS	(4) EXP 2 HEATER .075 MA ≤ 60 HRS	A	–
	X		24 HRS	(8) EXP 3 (1.5V) + FLASH CKT .093A (K3)	A	K3

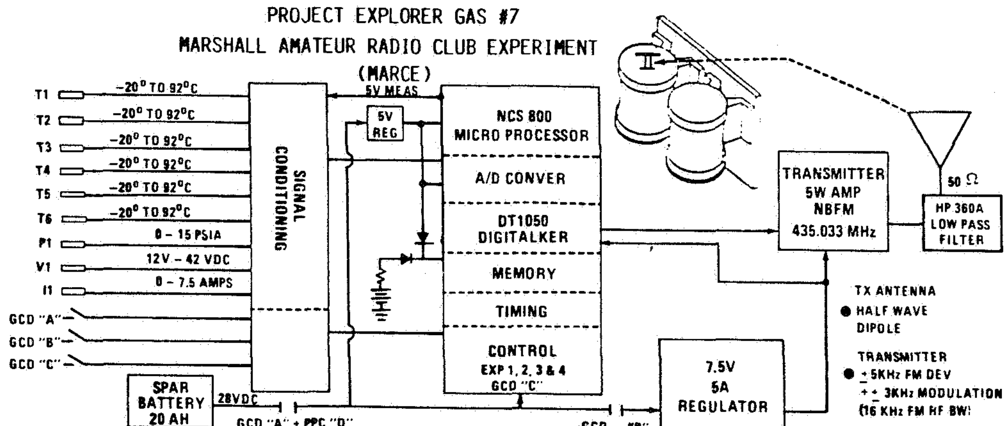
LEGEND:
(X) [X] KEYS FOR POWER PROFILE
SEE FIGURES 2, 2.1 & 2.2

(1) DURING NON TRANSMISSION PERIODS (3-8 HOURS)
(2) IMMEDIATELY PRIOR TO END OF 120 HOURS

TABLE 1

EFS 3-29-84

PROJECT EXPLORER GAS #7
MARSHALL AMATEUR RADIO CLUB EXPERIMENT
(MARCE)



NO.	EXPERIMENT DATA NAME	LOCATION	MEASUREMENTS NO.	TYPE
1.	ALLOY SOLIDIFICATION	A&M UNIV HSV, AL	1	T1 OVEN 1
			2	T2 OVEN 2
2.	PLANT PHYSIOLOGY	UNIV OF ALA HSV, AL	3	T3 EXP 2
3.	CRYSTAL GROWTH	UNIV OF ALA HSV, AL	4	T4 EXP 3
4.	AMATEUR RADIO	MARC – MSFC, AL		
INTEGRATION A	CONTAINER TEMP		5	T5
B	BATTERY TEMP		6	T6
C	BATTERY VOLTAGE		7	V1
D	BATTERY CURRENT		8	I1
E	CONTAINER PRESSURE		9	P1
F	GCD "A" + PPC "D"	AFT FLIGHT DECK	10	TURN GAS 007 ON/OFF
G	GCD – "B"	AUTONOMOUS	11	RADIO TX PWR
H	GCD – "C"	PAYLOAD CONTROLLER (APC)	12	"ON" SIGNAL FOR EXP 1, 2, 3, & 4

SAMPLE DATA:

FORMAT A

QST QST QST FROM WA4NZD TIME 00000 (EXP ELAPSED TIME
STATUS 10, DATA 012 014 014 014 015 012 255
135 255, FROM WA4NZD OUT

FORMAT B (WHEN EXPERIMENT 1 IS ON)

QST QST QST FROM WA4NZD TIME 00003
STATUS 1 0 DATA 015 014 013 012 015 013 255
180 255 TIME 0000 STATUS
0A DATA 3F 4A 3B 3C 3D 42 AF A2 FROM WA4NZD OUT

GROUND STATION REQUIREMENTS:

435.033 MHz ANTENNA & FM RECEIVER
ANTENNA: CIRCULAR POLARIZATION ≥ 10 DB GAIN
FM RECEIVER ≤ 1. μV 28 KHz RF BANDWIDTH
CASSETTE RECORDER – VOICE
FOR OSCAR A0-10 RELAY, 2 METER OSCAR
ANTENNA & RECEIVER

EFS 1-25-84

FIGURE 1

2098-84

PROJECT EXPLORER
GAS 007

VOICE MESSAGE FORMATS

FORMAT A:

QST QST QST FROM WA4NZD TIME 00000
STATUS 10 DATA 012 014 014 014 015 012 225
135 255 FROM WA4NZD OUT

FORMAT B: (WHEN EXPERIMENT 1 IS "ON")

QST QST QST FROM WA4NZD TIME 00003
STATUS 10 DATA 015 014 013 012 015 013
255 190 255
TIME 0000 STATUS OF DATA 3F 4A 3B 3C 3D
42 AF A2 FROM WA4NZD OUT

NOTES: 1. DATA TIME AND STATUS WILL VARY
2. MEASUREMENT LIST. STATUS DICTIONARY AND DATA CURVES REQUIRED TO READ MESSAGES

EFS 1-26-84

GAS007 MESSAGE
DESCRIPTION

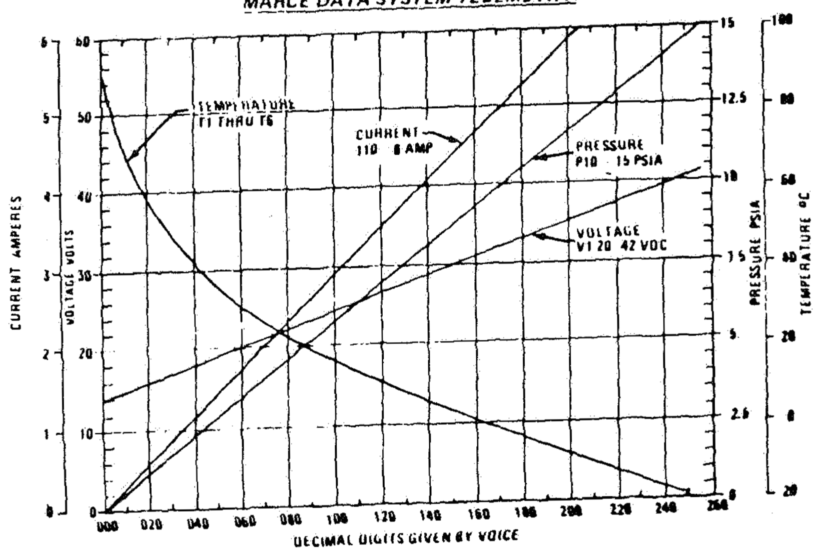
QST QST QST

- GENERAL CALL TO ALL RADIO AMATEURS AND ARRL MEMBERS
  - FROM WA4NZD
    - IDENTIFICATION FOR THE MARSHALL AMATEUR RADIO CLUB
  - HOURS, MINUTES 00000
    - EXPERIMENT ELAPSED TIME, STARTING WITH START OF EXPERIMENTS TURN ON
  - STATUS HH
    - A HEXIDECIMAL SYSTEM HAS A BASE OF 16 AND USES 0 THRU 9, A THRU F TO INDICATE THE DECIMAL VALUES 0 THRU 15

CONDITION	STATUS	HEXADECIMAL
A/D CONVERTER FAILURE	0	01
CANISTER PRESSURE TOO LOW	1	02
TRANSMITTER ON TOO LONG	2	04
GCD "B" TRANSMITTER RELAY OFF	3	08
GCD "C" CONTROL RELAY OFF	4	10
EXP # 1 OVER TEMPERATURE	5	20
EXP # 2 OR # 3 ARE ON	6	40
BATTERY VOLTAGE IS TOO LOW	7	80

EXAMPLE OF "STATUS A1"	VALUE
A/D C ERROR	01
EXP # 1 OVER TEMP	20
BATTERY V. TOO LOW	80
	A1

GAS 007
MAHCE DATA SYSTEM TELEMETRY



GAS 007
EXPERIMENT 1 TELEMETRY CONVERSION FORMAT B

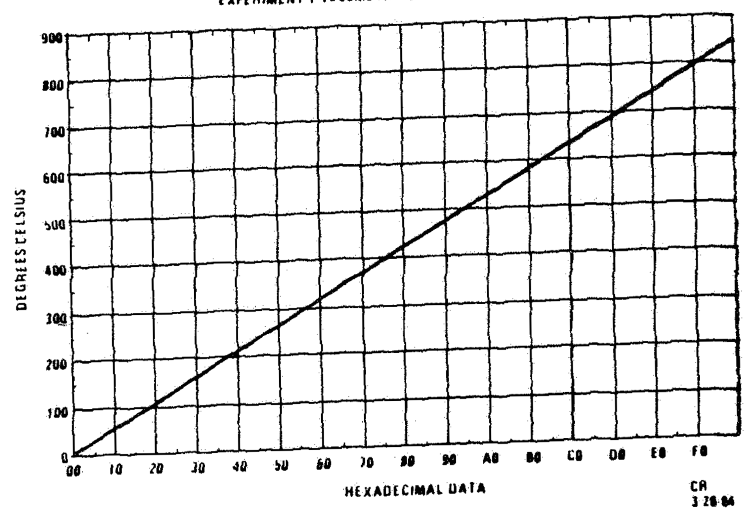
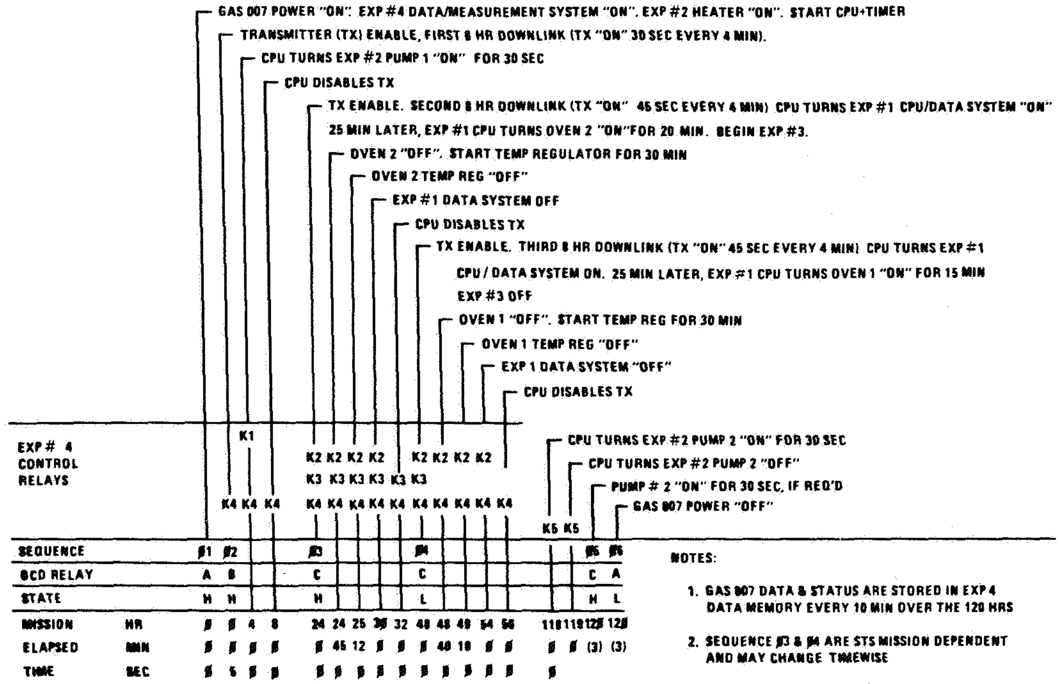


FIGURE 2

GAS 007 MISSION TIMELINE AND PAYLOAD FUNCTIONS



NOTES:

1. GAS 007 DATA & STATUS ARE STORED IN EXP 4 DATA MEMORY EVERY 10 MIN OVER THE 120 HRS
2. SEQUENCE Ø3 & Ø4 ARE STS MISSION DEPENDENT AND MAY CHANGE TIMEWISE
3. SEE PARD TABLE 3.2.2-2 EFS 4-16-84

GAS 007 SECOND DOWN LINK POWER PROFILE

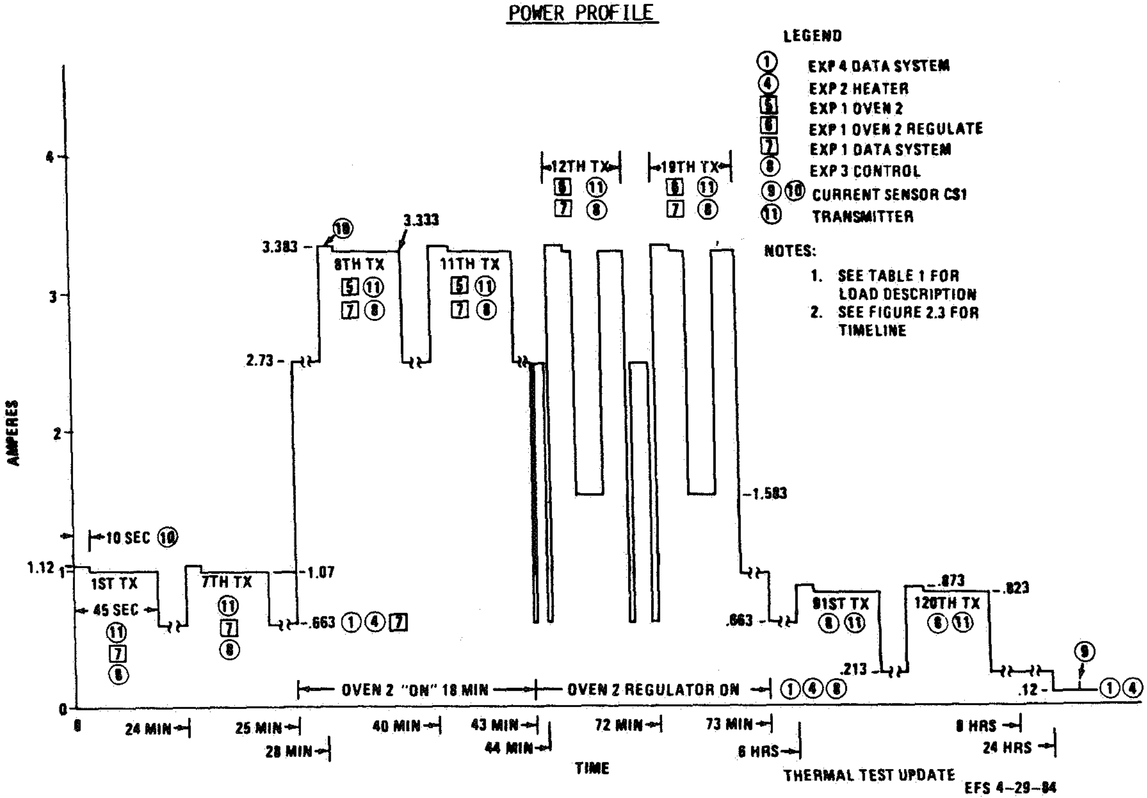


FIGURE 3

GYPSY MOTHS AND AMERICAN DOG TICKS: SPACE PARTNERS

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During the flight of Skylab IV (86 day orbital flight around the earth), the effects of zero gravity on the diapause (hibernation) of gypsy moth, Lymantria dispar (Linnaeus), eggs was studied. The rationale was that the intracellular organization of the embryonic brain and membrane permeability might be disturbed by zero gravity so that the normal obligatory 6-9 month egg diapause might be prematurely broken.

This study was described by Sullivan et al (1974); the following extract summarizes the results. "Five hundred eggs collected from nature at State College, PA, on Oct 1, 1973 (estimated to have been layed the 1st or 2nd week in July), were labeled wild, held at 4°C from Oct. 2-30, and placed in the space package. Five hundred eggs layed from Sept. 1-9, 1973, by a laboratory reared strain, 2nd generation, at the Methods Development Laboratory, USDA, APHIS, Otis Air Force Base, were fully embryonated by Oct. 10, were chilled at 4°C from Oct. 10-26, labeled tame, and and placed in the space package. The total weight of the package (Egg Demonstration Vial Assembly, EDVA) was less than 1 oz (28.3 g). A similar ground control was packaged in the same manner. The EDVA was taped to the IMSS locker in the orital workshop at ward room entrance and 1 crewman made daily observations of the EDVA to ascertain egg hatch. A small but significantly greater number of insects hatched when exposed to zero gravity in Skylab 4 than when maintained as ground control (7 vs 0); however, more work is required to demonstrate conclusively the principle tested.

After return to earth, most of the remaining Skylab 4 and ground control eggs were conditioned to induce hatching by either placing them at 4°C for 30-120 days and returning them to 22°C, or by holding them at 22°C for the duration of the experiment. A total of 10 gypsy moth eggs hatched and 1 insect, a female flown in Skylab 4, survived to the adult stage at Otis, MA, and was mated to a normal male. The resultant egg mass was conditioned at 4°C for the normal period of time, but there was no hatch when returned to 22°C; the hatch in the control egg mass was 22%.

"Astromoth I" was returned to Beltsville and studied by Dr. Edward L. Todd, Lepidoptera Specialist at the National Museum. He stated that the specimen was normal, larger than usual, but within normal limits.

Electronic micrographs of the sections through the brain of the embryos from eggs that were subjected to conditions in space were compared with similar sections prepared from ground controls. In the limited number of sections examined, it appeared that small osmophilic granules were more numerous in the cytoplasm of cells from insects that were not on the Skylab mission than in those that were. This osmophilic material could represent neurosecretory substances. This suggests that some feature of the space flight--in particular weightlessness--may have resulted in a release of neurosecretory material, since a similar reduction was not noted in controls maintained under atmospheric conditions similar to those on Skylab. Because of the limited number of samples--5 from each experimental group were subjected to microscopy--this conclusion must remain a tentative one, to be further tested in future space flights." According to Loeb and Hayes (1980) a method has been developed for studying brain neurosecretions during diapause and diapause breaks in embryonated larvae of the gypsy moth.

Eleven years have passed and the development by NASA of the small self-contained payload program for shuttle missions has made available a research payload container that is suitable for our type of experiments. New packets of gypsy moth eggs and possibly engorged female American dog ticks, Dermacentor variabilis (Say), and cartridges of jelled agar will be secured to and rolled in a stiff cotton mesh, placed in a nylon mesh bag, and packed into a Get Away Special (GAS) container without the use of a support structure. The cartridges of jelled agar will maintain the humidity within the sealed canister. A Tattletale® thermograph will form the core of the experimental package.

Engorged female American dog ticks overwinter in diapause, which is normally broken in late March by increased photoperiodism. For this experiment, engorged female ticks will be induced into a prearranged diapause, beginning in August rather than as normally occurs in October. Under controlled laboratory conditions, the female ticks should begin oviposition when daylength exceeds 10 hours. The affects of weightlessness plus total darkness for the duration of containment may alter the photoperiod requirement needed for oviposition. Also, the effects of weightlessness may alter physiological and reproductive functions.

The objectives are: (1) to reevaluate the effects of zero gravity on the termination of diapause/hibernation of embryonated gypsy moth eggs, (2) to determine the effect of zero gravity on the ovipositions and subsequent hatch from engorged female American dog ticks that have been induced to diapause in the laboratory, and (3) to determine whether morphological or biochemical changes occur as a result of the exposure in Skylab, after questions posed in objectives (1) and (2) are answered.

References

Loeb, M. J. and D. K. Hayes. 1980. Neurosecretion during diapause and diapause development in brains of mature embryos of the gypsy moth, Lymantria dispar. Ann. Entomol. Soc. Amer. 73(4):432-436.

Sullivan, W. N., D. K. Hayes, M. S. Schechter, T. McIntyre, D. R. Morrison and M. Fisher. 1974. Space studies with insects. Bull. Entomol. Soc. Amer. 22(1):15-16.

Nuclear Particle Detection Using a Track-Recording Solid

by
Mark Weber and David Weber

Abstract

This paper details the design of the nuclear particle detector located in Purdue University's "Get Away Special" package which was flown aboard STS-7 in June, 1983. The experiment consisted of a stack of particle-detecting polymer sheets. The sheets show positive results of tracks throughout the block. A slide of each sheet has been made for further analysis. Recommendations for similiar experiments performed in the future are discussed.

1. Introduction

This experiment was one of three that were chosen to ride in Purdue's 2.5 cubic foot canister. The original proposal was suggested by Christopher Wachs, a student at Purdue. The other two experiments were to study the effect of gravity on seed germination and to film the motion of mercury in a clear liquid under low gravity. Electrical and mechanical malfunctions prevented the proper operation of these experiments. The radiation experiment was divided into two parts: radiation badges and the main detector. The badges were used to give a rough reading to back up data from the main detector. The main detector itself was designed to record the passing of particles in the atmosphere. Being entirely passive, it was not effected by the other malfunctions.

2. Film Badges

Film badges are used in nuclear related industries to keep track of exposure to personel. They are differentiated from each other by the type of radiation and energy range that they are sensitive to. Two types of badges were included in the canister. The badges chosen were the types T1 and B1 from the R. S. Landauer company. These can detect neutron, x-ray, gamma, and beta doses. Two of each type were obtained from the Bionuclear Department of Purdue University, one being a control and the other placed in the canister. They were returned to the Bionuclear Department to be processed normally.

The badges do indicate that higher than normal radiation levels were present which is to be expected. The energy deposited appeared mainly as gamma and x-ray radiation along with traces of beta and fast neutron radiation. One of the badges also gave a "high energy" indication. Both badges indicate a general dose to the experiment of twenty millirems which is thought to be a realistic value. Since the detector material is not directly sensitive to the radiation indicated by the badges, it has not been determined whether there are any concurrent conclusions to be drawn.

3. Main Detector

In recent years, dielectric solid particle detectors have become a viable alternative to older, conventional methods for the detection and measurement of radiation. Charged particles passing through the detector material leave a path of damage on the molecular scale. If the detector is plastic in nature, it can then be etched in a caustic solution which preferentially attacks the damaged spots rendering them visible under an ordinary light microscope. If the material is an emulsion, it can be developed in a method similiar to that done for ordinary camera film also yielding a track that can be studied.

The original experiment idea used a silver halide emulsion, which when processed into thin sheets (called pellicles) of the proper dimensions, would be stacked and used as the detection block. As charged particles pass through the material, they would be activated similiar to camera film and could be developed to show the tracks. The manufacture of the emulsion pellicles and the developing thereafter is a timely and complicated process. This, along with its sensitivity to light and high mechanical pressure, and a need for a well controlled atmosphere, made the emulsion an impractical choice for a detector material.

As the experiment developed, it became evident that polymers would be a much better choice for a detector material. Two were singled out as being alternatives: cellulose nitrate and allyl diglycol polycarbonate (trademark by Pittsburgh Plate Glass as CR39). After some investigation, it was found that in addition to greater sensitivity and better physical characteristics, CR39 was cheaper and could be purchased in the amount needed. The cellulose nitrate material sold by Kodak was sufficient for experimental requirements but could not be purchased in the quantity desired. A sample of CR39 was acquired and tested by exposing it to an alpha source. Upon etching in a solution of sodium hydroxide and noting positive results, it was decided to go with the CR39 monomer.

In addition to the plastic, a boron converter was added in order to detect neutrons through secondary emissions of alpha particles. Alphas are the result of neutron capture in a boron nucleus. This was made by mixing boron oxide with polyeurethane wood finish and then "painting" it on a two inch by three inch piece of paper. After drying, it was placed on the stack of detector material.

The monomer was received in sheets of .025 inch in thickness. It was then cut to two inch by three inch rectangles by scribing and breaking it in a manner similiar to that used for glass. The box was cut from sheet aluminum (four sides, top and bottom) so as to give inside dimensions of two inches by three inches by two inches. (See figure 1.) A flange used to secure the box was machined as an integral part of the bottom plate. It was held together with brass metal screws and tapped holes. Each of the seventy-five sheets were engraved with a number and placed into the box along with the previously mentioned boron converter and then bolted onto the canister base.

4. Development

Upon receiving the canister from NASA after the flight, the box was unbolted and stored until the fall school session. At this time the sheets were removed from the box. A Teflon rack was made to hold the sheets during etching. Forty sheets at a time were etched in a 6.25 normal solution of sodium hydroxide kept at approximately fifty degrees celsius by a hot plate. To etch all the sheets the process was carried out twice. Each time two control sheets were included in the solution. The total etching time was eleven days for each group. During this time the solution was stirred daily. Upon completion of the etching, the plastic was visibly spotted with what appeared to be pits. The sheets were rinsed and then dried.

5. Results

A visual inspection of the sheets has varified that the experiment did detect particles. The particles are revealed by conical pits in the surface of the plastic. (see figure 2.) The shape of the surface pattern can be used to determine the angle at which the particle entered the plastic. Some of the particles left only a single pit. Others left a

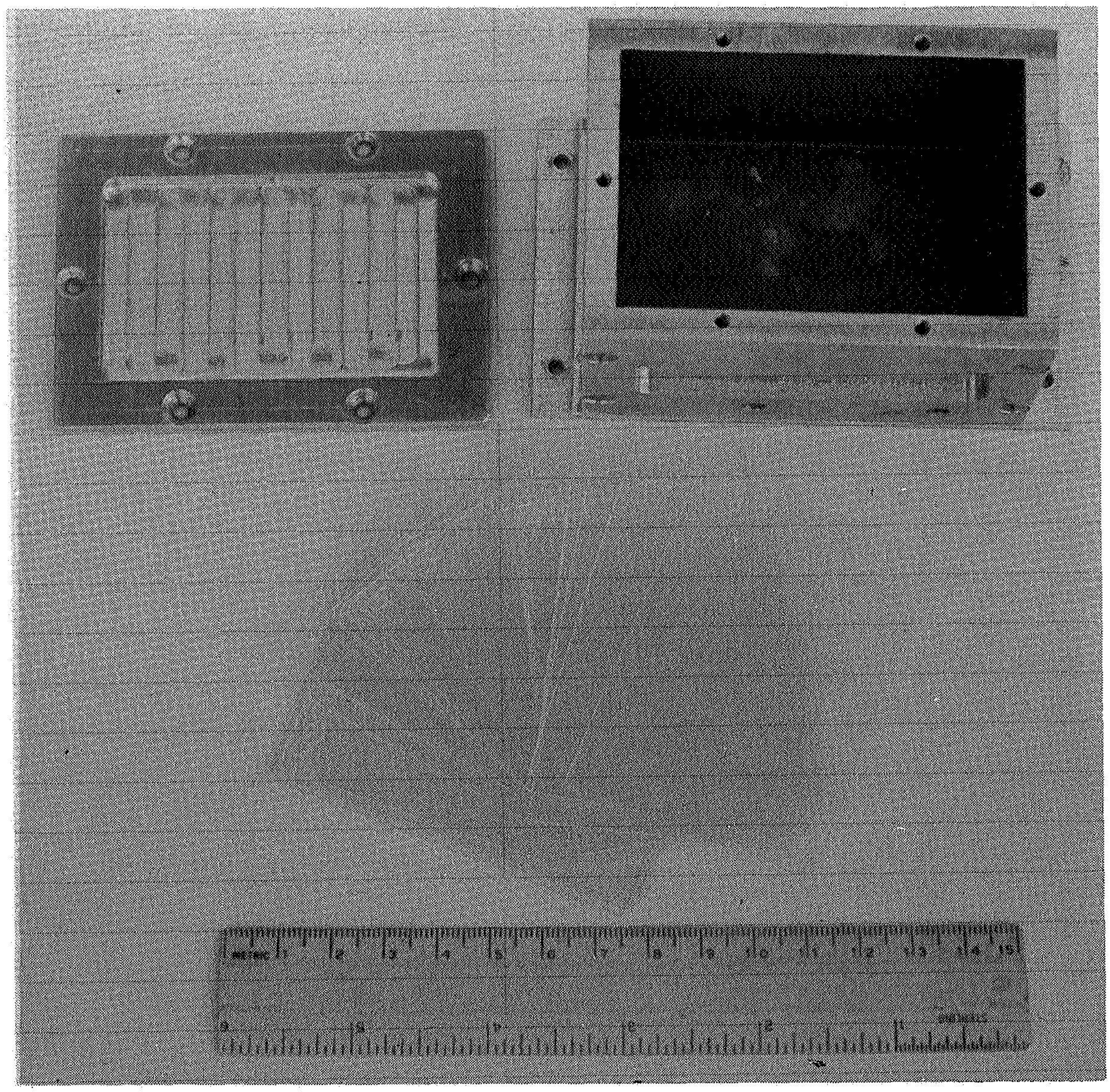

Fig. 1. The components of the main detector of the radiation experiment. Shown are the container (upper right), its lid (upper left), and the sheets of CR39 plastic.

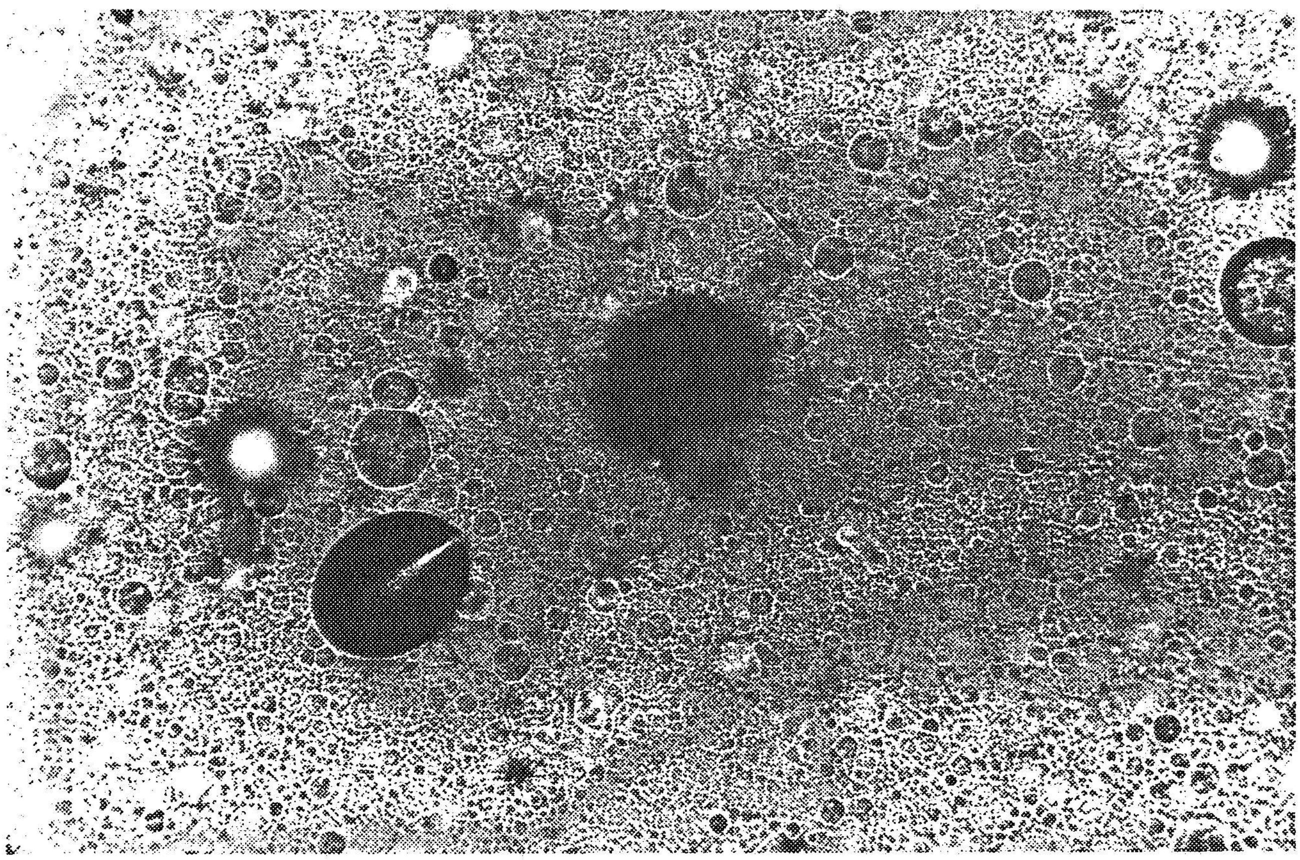

Fig. 2. An enlargement (20X) of a portion of the top sheet of plastic (the one next to the boron impregnated paper), showing the conical entrance hole of a particle. The blurred exit hole is also visible.

pair of cones in the sheet. This indicates where the particle entered the top of the sheet and then exited at the bottom. The longest of these tracks left pairs of cones through the top twelve sheets. However, most of the tracks are only single pits or in two or three sheets. It is interesting to note that some of the tracks start and end in the middle of the block.

The analysis of the sheets has been complicated by pits caused by the etching that are not particle tracks. These are easily distinguished since the pits are rounded as opposed to the pointed track pits. However, this requires that each pit be looked at to determine if it is a track rather than just counting the particles on the surface of each sheet. A count of the particles on the sheet next to the boron is about fifteen to twenty. The middle sheets are less dense than the boron coated end.

6. Future Plans and Recommendations

The results of the experiment are not obvious at first glance and an intensive catalog of all tracks needs to be made. This is a major activity and will take some time and effort. This will enable identification of particle types and energies. Also track direction relative to the shuttle and radiation planes in space will be determined.

Experience with this experiment has brought out some methods that should be used in any similiar experiments. The sheets should have an index of some sort that will allow the tracks to be accurately realigned after development. Products that reduce the amount of irrelevant surface pitting should be used to ease counting of the tracks. A small computer could be used to speed the numerical calculations and keep a catalog of the tracks. If the expense is not prohibitive, another detector such as cellulose nitrate would be used to verify data from the CR39 sheets.

7. Acknowledgements

The authors would like to gratefully acknowledge the help of Dr. John Snow (Department of Geosciences), the project faculty advisor; Dr. Richard Sanderson for the use of his microscope; the PUR-1 nuclear staff for the use of their alpha sources and the Purdue Bionuclear Department for the use of their film badges.

DESIGN AND DEVELOPMENT OF SHUTTLE GET-AWAY-SPECIAL EXPERIMENT G-0074

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Abstract

This paper describes a McDonnell Douglas Astronautics Company (MDAC) sponsored Get-Away-Special (GAS) experiment to investigate more versatile, lower cost surface tension propellant acquisition approaches for future satellite and spacecraft propellant tanks. The experiment, designated G-0074, is designed to demonstrate a propellant off-load capability for a full-tank gallery surface tension device, such as that employed in the Shuttle Reaction Control Subsystem (RCS), and demonstrate a low-cost refillable trap concept that could be used in future orbit maneuver propulsion systems for multiple engine restarts. The experiment consists of a Plexiglas test tank, movie camera and lights, auxiliary liquid accumulator, control electronics, battery pack, and associated valving and plumbing. The test liquid is Freon 113, dyed blue for color movie coverage. The fully loaded experiment weighs 106 pounds and will be installed in a NASA five-cubic-foot flight canister. Vibration tests, acoustic tests, and high and low temperature tests were performed to qualify the experiment for flight. The experiment will be delivered to NASA-Kennedy Space Center (KSC) on 9 June 1984 and is scheduled to be flown on the STS-41-F mission on 23 August 1984.

I. Introduction

The G-0074 GAS experiment has been part of an on-going research and development effort at MDAC to evaluate advanced surface tension propellant acquisition concepts. Initial planning for the experiment was begun in 1981 and a NASA Payload User's agreement was signed in April 1982.

The objective of the experiment is to demonstrate an off-load capability for a full-tank propellant acquisition system, a capability that does not exist with current full-tank surface tension devices such as the Shuttle RCS propellant acquisition system (Fig. 1). In the acquisition system shown in Fig. 1, the gallery legs must be kept full of propellant to ensure gas-free propellant delivery to the engines. This is not possible when the tank is launched with a partial propellant load because, uncovered, the forward gallery leg screens are not able to retain propellant during launch acceleration. The G-0074 experiment is designed to solve this problem by demonstrating passive gallery fill following orbit insertion. In addition, it will demonstrate a passive refillable trap concept that could be used in an orbit maneuver propulsion system to provide multiple engine restart capability.

The following paragraphs describe the design and operation of the experiment and tests performed to qualify the experiment for flight environments.

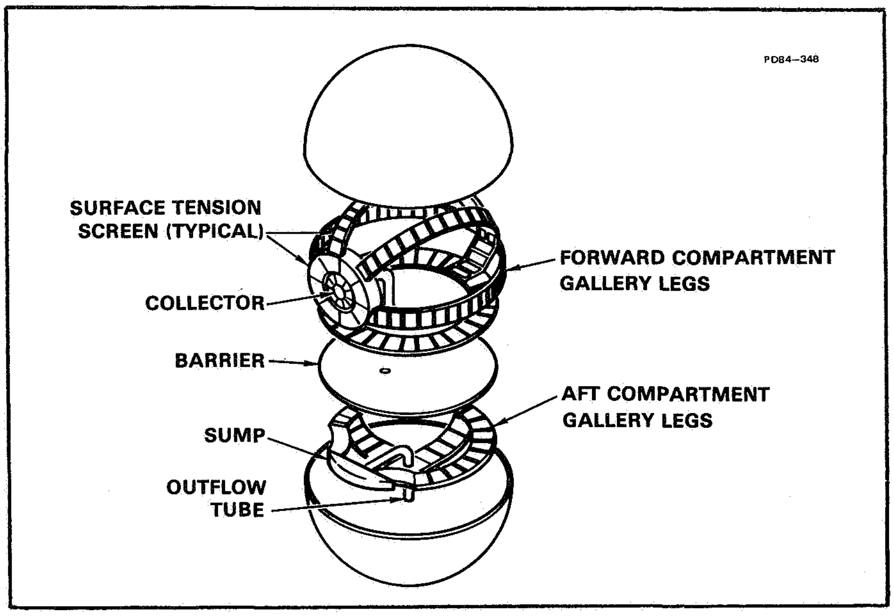

Fig. 1 Shuttle RCS Propellant Acquisition Device

II. Design and Operation

The complete flight payload (Fig. 2) consists of a Plexiglas test tank, movie camera and lights, auxiliary liquid accumulator, control electronics, battery pack, and associated valving and plumbing. The entire payload with support structure will be installed within a NASA-supplied, five-cubic-foot flight canister. The payload support structure is a 6061-T6 aluminum frame assembly that is cantilevered from a mounting plate at the top of the canister and supported laterally by four "bumpers" at its opposite end.

The test tank (Fig. 3) is a bolted assembly consisting of a cylindrical Plexiglas section, an aluminum forward dome, and an aluminum aft end plate. The tank is divided into forward and aft compartments by an internal Plexiglas bulkhead. The three gallery legs in the forward compartment are made of Plexiglas to allow visual (movie) evaluation of passive gallery fill. Each gallery leg has a flat, stainless steel screen surface along its outer face (adjacent to the tank wall) and a vent screen inside the forward vent baffle assembly. The internal bulkhead assembly contains a tapered Plexiglas vent stack to provide an exit passage for entrapped gas during passive fill of the aft trap compartment. The vent stack is covered by two perforated plate discs at its forward end. Gallery leg dimensions, screen mesh sizes, and perforated plate hole sizes are presented in Table I. The variation in shape, cross section, and screen mesh for the three gallery legs will allow us to acquire parametric data.

The tank operating sequence is shown in Fig. 4. The tank will be launched with a partial liquid load (Freon 113) in the forward compartment and a nearly empty aft compartment. During the zero-g interval following main engine cutoff, the three gallery legs will fill by capillary pumping. The baffle assembly at the forward end of the tank keeps the gallery vent screens dry until the gallery fill process is complete.

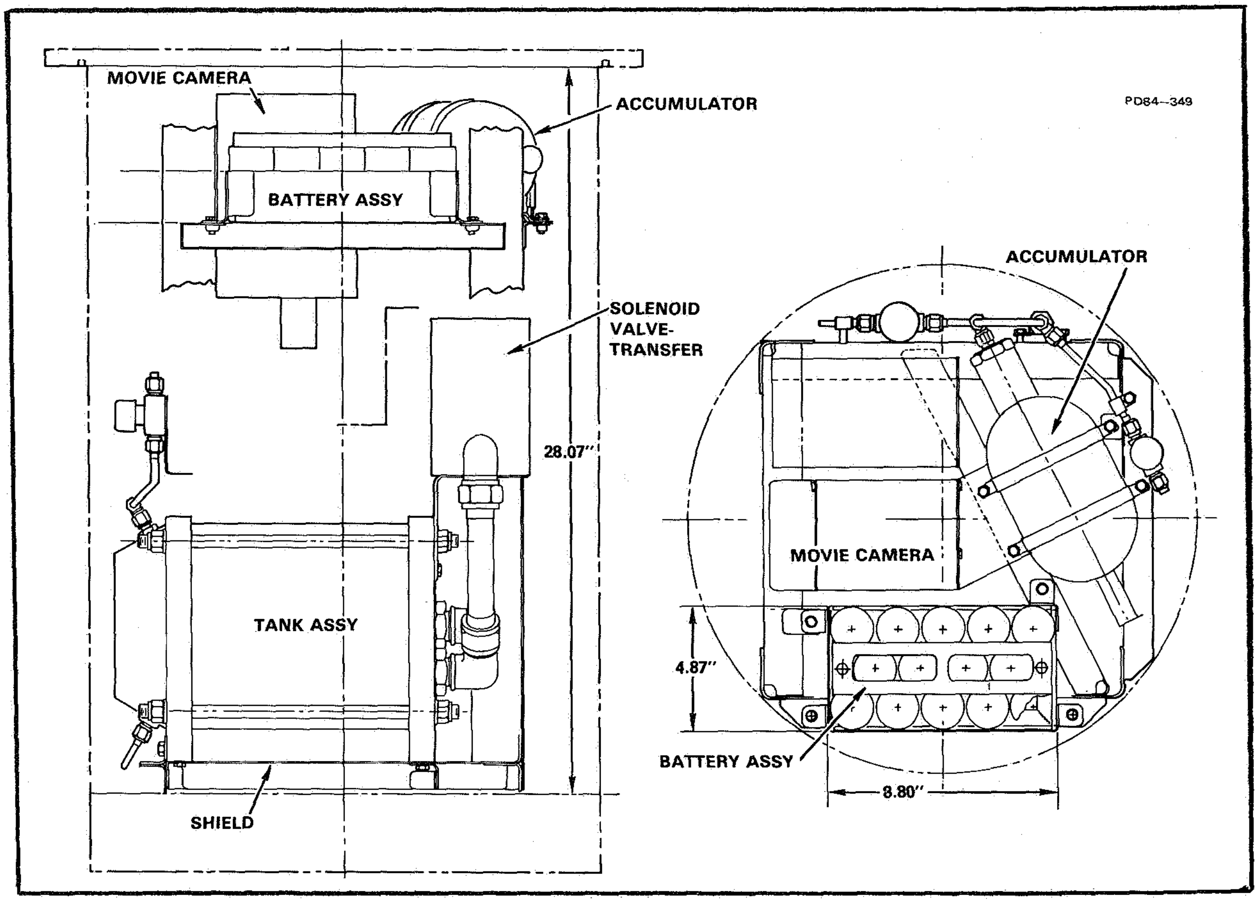

Fig. 2 Experiment Layout

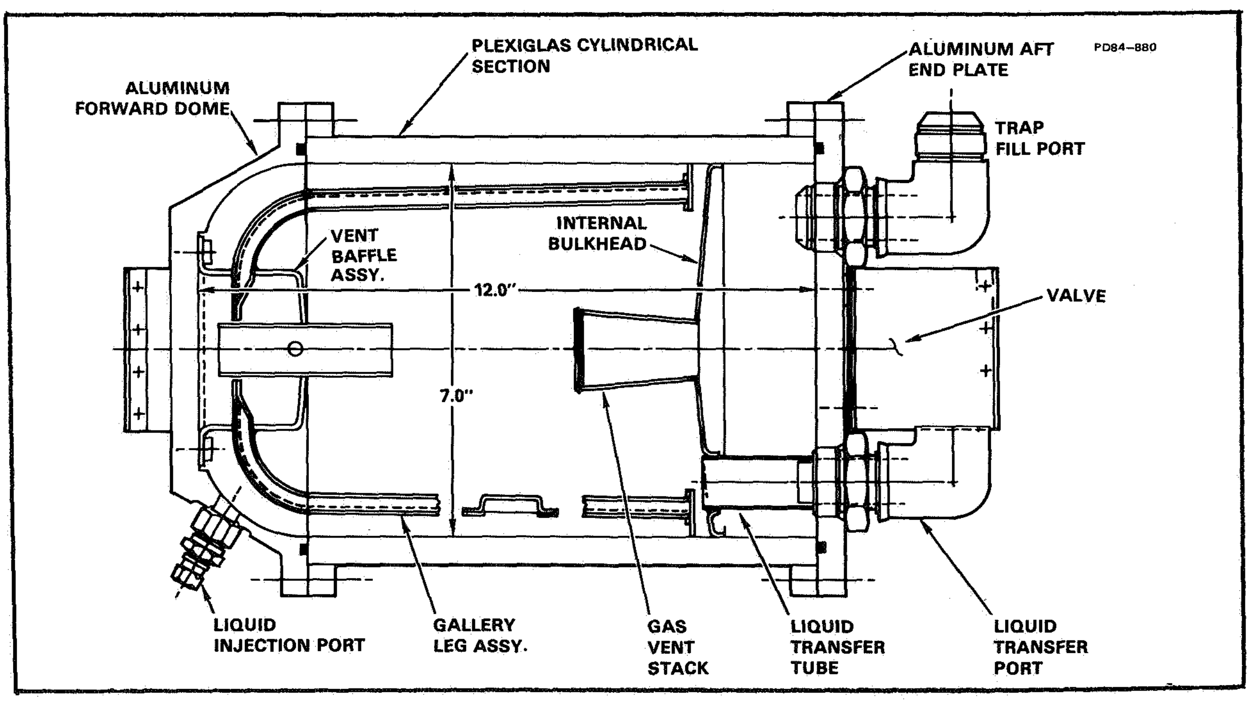

Fig. 3 Plexiglas Test Tank

Table I Gallery Leg and Vent Stack Perforated Plate Geometry

PD84–360

GALLERY LEG DESIGN CHARACTERISTICS:

	SHAPE	CROSS SECTION	GALLERY SCREEN MESH	VENT SCREEN MESH
GALLERY LEG NO. 1	RECTANGULAR	0.25 IN. x 1.00 IN.	150 x 150 PSW(1)	150 x 150 PSW
GALLERY LEG NO. 2	RECTANGULAR	0.25 IN. x 1.00 IN.	30 x 250 TDDW(2)	30 x 250 TDDW
GALLERY LEG NO. 3	TRAPEZOIDAL	0.25 IN. HIGH; 0.25 IN. & 1.00 IN. BASES	30 x 250 TDDW	30 x 250 TDDW

(1) PSW – PLAIN SQUARE WEAVE
(2) TDDW – TWILLED DUTCH DOUBLE WEAVE
} ALL SCREEN MATERIAL IS STAINLESS STEEL

VENT STACK PERFORATED PLATE HOLE SIZES:

	HOLE DIAMETER, IN.	% OPEN AREA
LOWER PLATE (1.0 IN. DIAMETER)	0.125	30%
UPPER PLATE (1.0 IN. DIAMETER)	0.250	30%

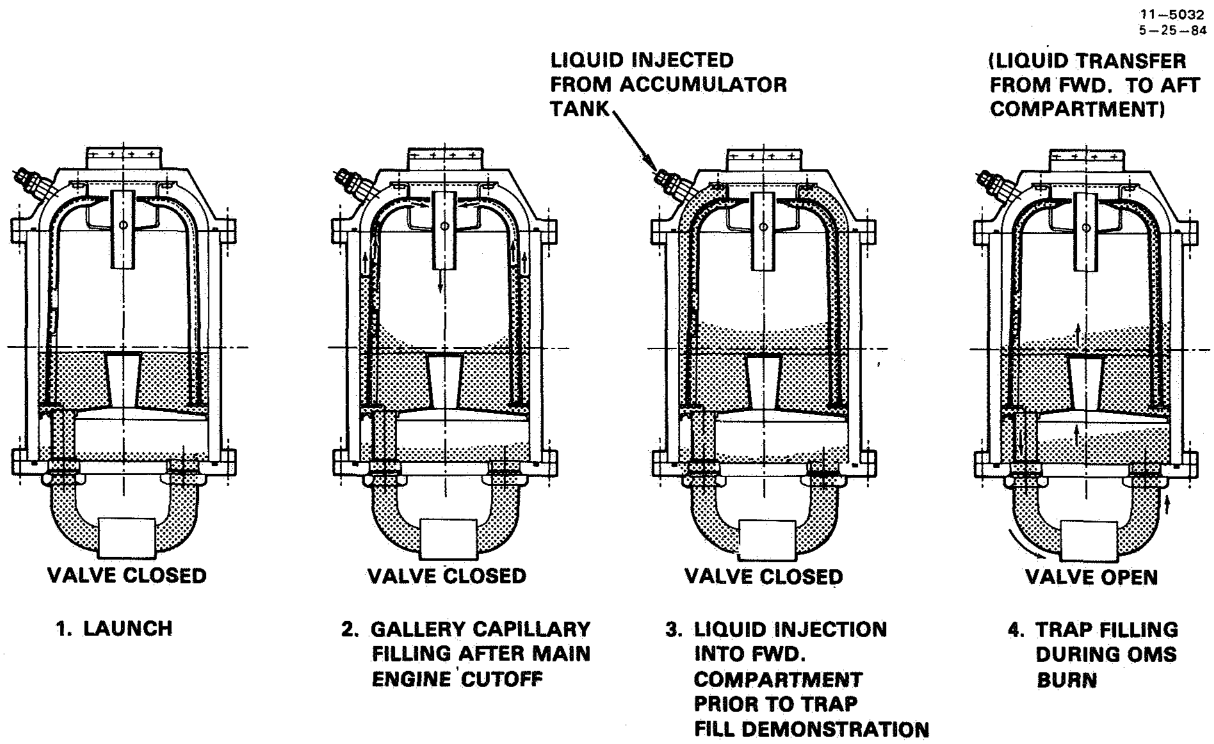

Fig. 4 Experiment Operating Sequence

The principle of gallery capillary pumping is illustrated in Fig. 5. The pressure, P_1, in the bulk liquid is higher than that in the gallery leg, P_2, for the common ullage pressure, P_a. The pressure differential (P_1 - P_2) results from differences in the meniscus radii at these locations in a low-g environment. As a result, liquid is pumped through the gallery leg in order to achieve a minimum free-energy position. During the gallery fill process the gas within the gallery legs is vented to the tank through the vent screens at the top of the gallery legs. The gallery fill rate is retarded by pressure losses due to liquid flow into the gallery legs, frictional and dynamic pressure losses due to liquid flow within the gallery legs, and pressure losses due to gas flow leaving the gallery legs. Predicted gallery fill times are shown in Fig. 6 as a function of gallery fill length. For the design gallery fill length of 6 inches, the maximum fill time (10.3 seconds) occurs for the rectangular leg with 30 x 250 twilled dutch double weave (TDDW) screen.

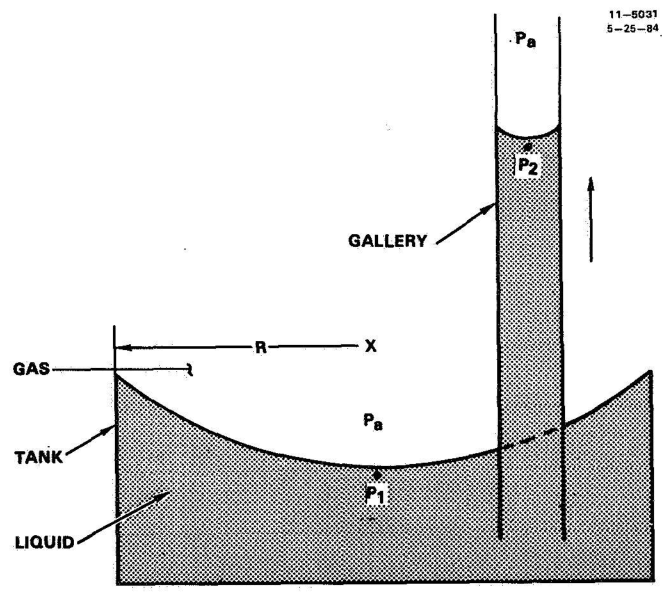

Fig. 5 Gallery Leg Capillary Pumping

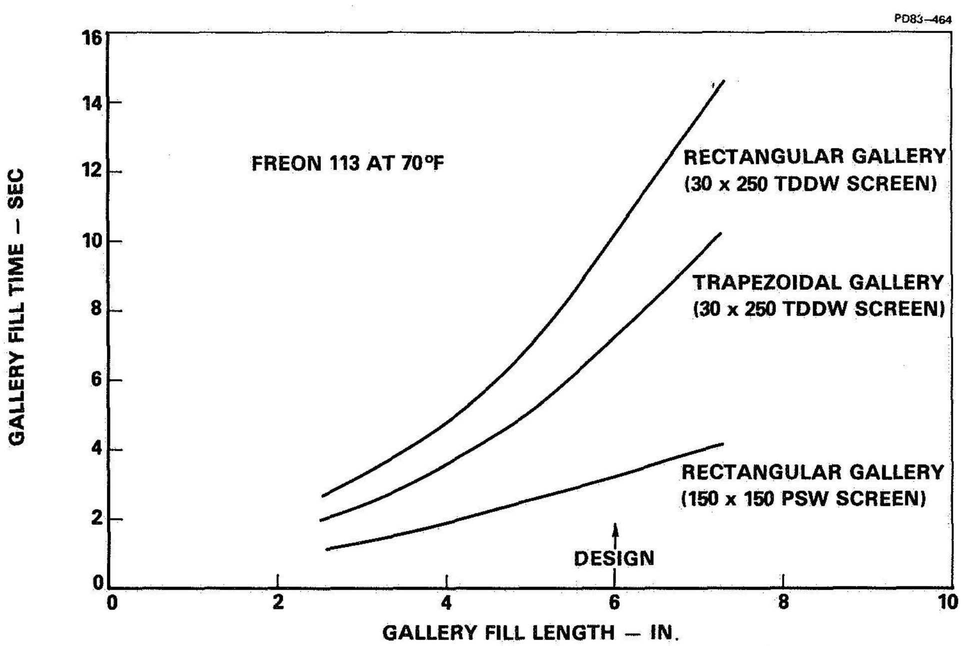

Fig. 6 Gallery Leg Fill Time

After the first Orbital Maneuvering Subsystem (OMS) burn, additional Freon 113 will be injected into the tank forward compartment from an auxiliary positive displacement accumulator in preparation for the trap filling experiment (Fig. 4). The trap filling experiment will be performed during the second OMS engine firing. The transfer valve at the tank outlet will be signalled open to allow liquid flow from the forward to aft compartment. During the burn, gas inside the aft compartment will be expelled through the vent stack perforated plates by the hydrostatic pressure imposed across the entrapped gas bubble, allowing the aft compartment to fill. The aft compartment fill rate is retarded by liquid flow pressure losses through the transfer line and valve and by gas flow pressure losses through the vent stack perforated plates. Predicted trap fill times are shown in Fig. 7 as a function of OMS acceleration level. For an OMS acceleration of 0.04 g's, the aft compartment fill time is approximately 30 seconds.

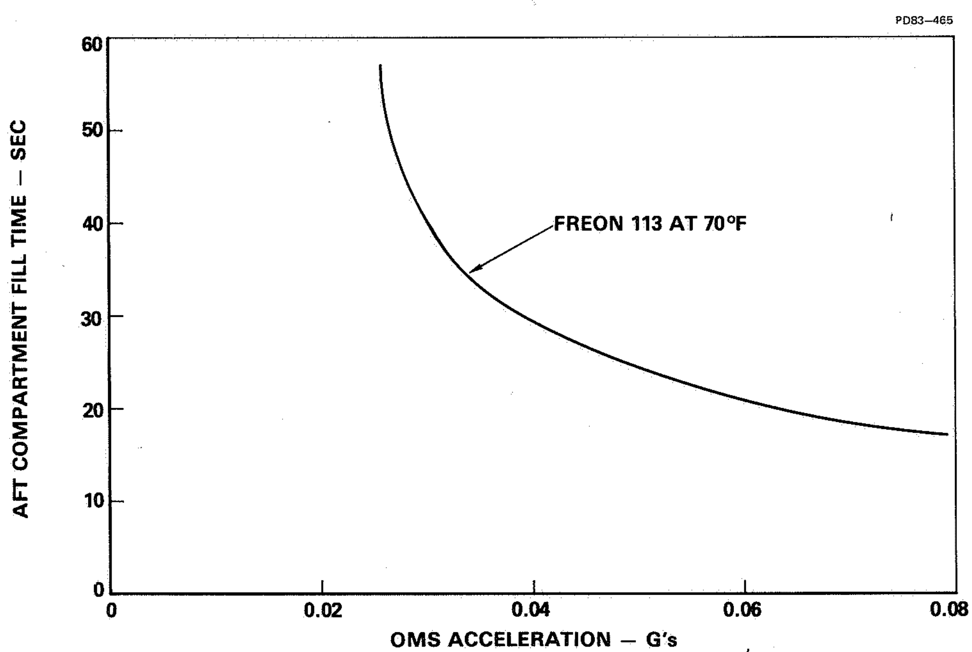

Fig. 7 Aft Compartment Fill Time

The experiment is controlled by an electronics package consisting of acoustic switches and timing circuits. At lift-off, the experiment will be activated using redundant acoustic switches that sense main engine ignition. The switches activate timing circuits that perform three functions: (1) turn on lights and camera for three minutes at main engine cutoff to monitor gallery leg filling; (2) activate a solenoid valve to inject liquid from the accumulator into the test tank in preparation for the trap refill experiment; and (3) turn on lights and camera and activate the test tank transfer valve for the trap refill experiment during the second OMS burn. A photograph of the acoustic switches and timing circuits is shown in Fig. 8 and photographs of the assembled experiment are presented in Fig. 9.

III. Testing

Environmental testing was performed to qualify the experiment for flight. The testing consisted of high and low temperature operating tests, vibration tests and acoustic tests.

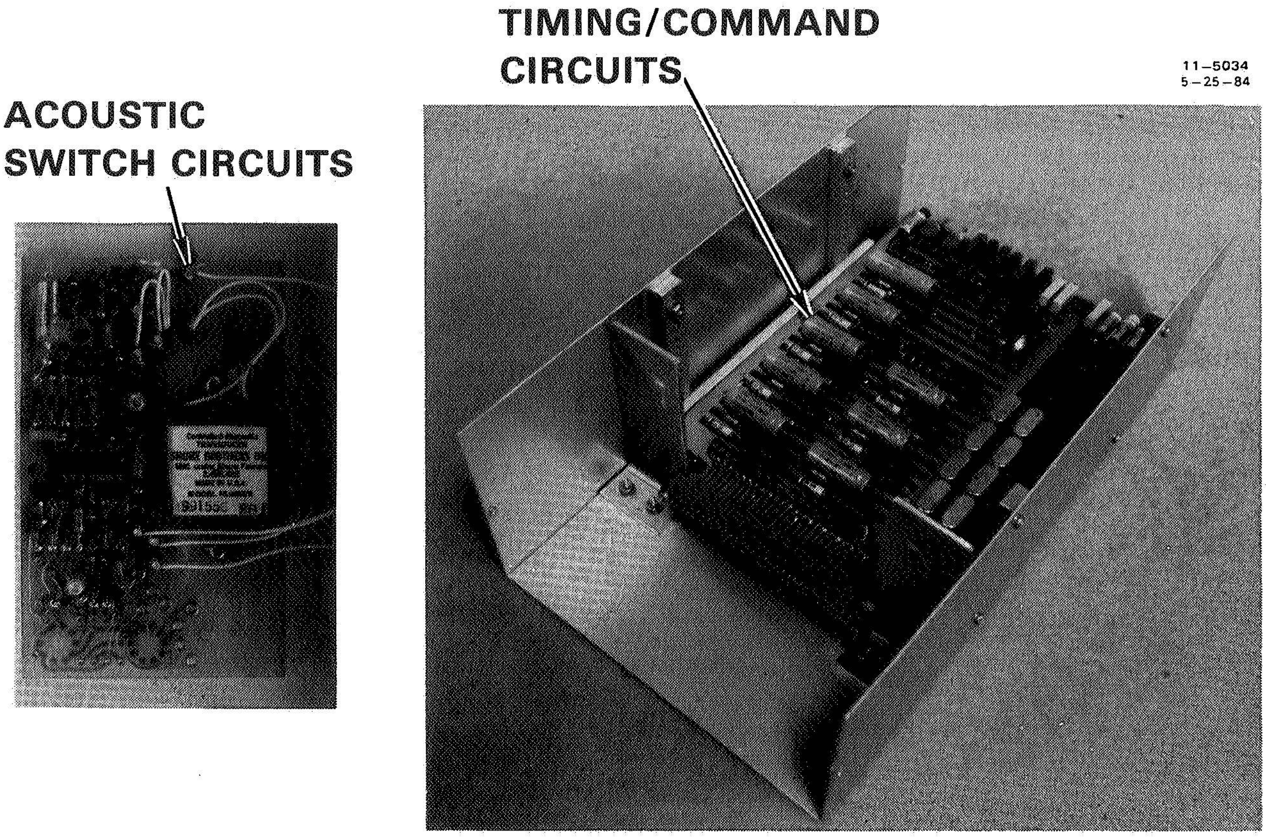

Fig. 8 Experiment Electronics

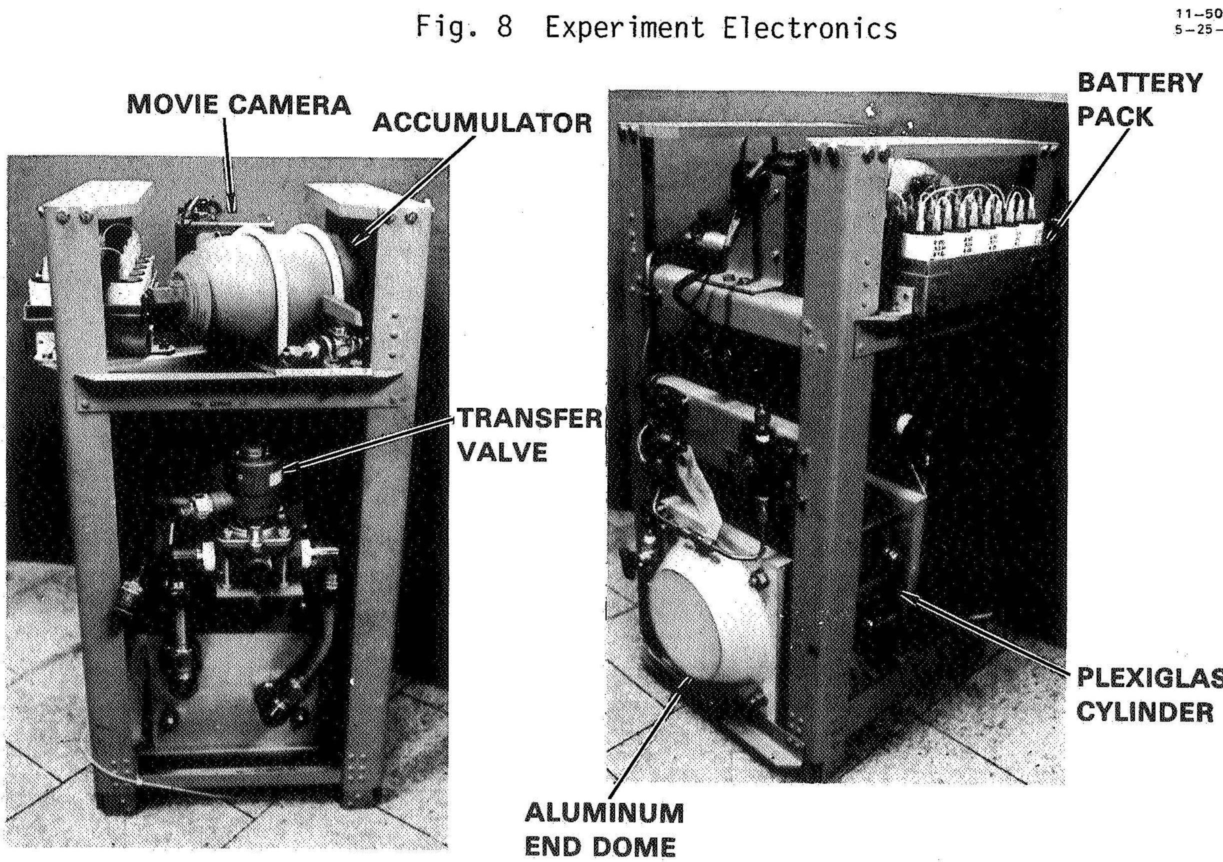

Fig. 9 G-0074 Experiment

The high temperature test was performed by installing the fully serviced payload inside an insulated thermal enclosure. Conditioned air at 150°F was circulated through the enclosure for a five hour period to bring the payload to an equilibrium temperature of 140°F. The payload was activated, and an entire mission sequence was run while maintaining the equilibrium temperature. There was no evidence of structural damage, and all light, camera, valve and switch functions occurred normally.

The vibration tests were performed with the fully serviced payload installed in a NASA shipping cylinder to simulate the flight canister. The imposed vibration spectrum (6 g_{RMS} - overall) was in accordance with the NASA flight specification for GAS payloads. Tests were performed in each of three axes (2 lateral and 1 vertical) for 40 seconds per axis. There was no evidence of structural damage as a result of the vibration tests.

An acoustic test was performed to verify the operational integrity of the payload following vibration testing. An acoustic environment was imposed which duplicated the sound pressure level and frequency spectrum measured inside the GAS canister on the STS-3 mission at liftoff. The payload was activated successfully with its acoustic switches at a threshold sound pressure level of 110 dB, and an entire mission sequence was run. All light, camera, valve and switch functions occurred normally.

The low temperature test was performed by installing the fully serviced payload inside the same thermal enclosure used for the high temperature test. Conditioned nitrogen at -20°F was circulated through the enclosure for an 18 hour period to bring the payload to an equilibrium temperature of -10°F. The payload was activated, and an entire mission sequence was run while maintaining the equilibrium temperature. There was no evidence of structural damage, but one valve (the accumulator solenoid valve) failed to operate. All other light, camera, valve, and switch functions occurred normally. The failure was traced to a faulty capacitor in the control circuit. The capacitor was replaced and a low temperature test was repeated successfully.

On the basis of these tests, the experiment was certified for flight.

IV. Summary

The Get-Away-Special experiment described in this paper will demonstrate technology for designing more versatile, lower cost surface tension propellant acquisition systems. It will demonstrate a full-tank gallery concept for future altitude control systems that can be off-loaded to provide enhanced mission flexibility. In addition, it will demonstrate a low-cost method for propellant acquisition in future orbit maneuver propulsion systems requiring large diameter propellant tanks.

The experiment has been fabricated and tested successfully to simulated flight environments. It will be delivered to NASA-KSC on 9 June 1983 and is scheduled to be flown on the STS-41-F mission on 23 August 1984.

An Investigation of the Phototropic Effect on Seedling Orientation in a Microgravity Environment: a Student Involvement Project

John W. Barainca

Brighton High School

The prospect of extended space flight and possible space colonization demands that on-board systems be developed to provide a continuing supply of food to spacecraft occupants. A study conducted by Boeing Aerospace for NASA's Controlled Ecological Life Support System (CELSS) looked into the needs of such future space missions and concluded that occupants of future space stations could survive more economically by growing their own food. Astronauts have always carried their own food and oxygen and have stored their waste, but weight penalties for longer missions and larger crews could prohibit storing and resupply. Two examples of missions which would benefit from recycling are earth orbiting scientific space stations and military command posts, both of which, if they could produce fifty percent of their food needs, would become cost effective in five to ten years.[1]

Various systems have been proposed to utilize waste products to grow algae and bacteria which would be useable for human nutrition. However, as a food source, algae has caused gastrointestinal problems.[2] Experience has also shown that even conventional food products in squeeze tubes and reconstitutable form do not provide the psychological satisfaction that accompanies conventional food. Experience with Skylab and the space shuttle has demonstrated that eating can be done in a quite normal way.

Research on cultivation of conventional food plants in a space environment began early in the space program. A flight of wheat seedlings in Biosatellite II, launched September 7, 1967, revealed that short periods of weightlessness do not disorganize the normal process of growing wheat. Only small deviations from normal physiology or behavior were found, which returned to normal after several hours.[3] However, the lack of typical shoot and root system in the wheat plant made it difficult to predict confidently the results of growing plants with more complex organization in the absence of gravitational force.[4] In addition, the seeds began germination before launch and were in orbit only forty-five hours. Either situation could affect the outcome.

A student-designed experiment to test phototropic response and flown in Skylab for twenty-two days resulted in a random growth of rice seedlings and little phototropism. The proposed explanation was that the auxin distribution system of plants depends on gravity and without it the auxins may have been dispersed unevenly, thus causing irregular stem and root growth.[5] More recently, a plant growth unit designed by NASA Ames Research Center to carry experiments by Dr. J. Cowles and Dr. W. Shield to study the effect of hypogravity on plant lignin flew on STS-3. The results demonstrated a more positive phototropic response.[6] Variations in experimental design and conditions have produced conflicting or inconclusive results; therefore, a need for more work in this area is evident. The Getaway Special Program, with its low cost, provides a means by which more experimentation on phototropism may be conducted. In response to this opportunity, teachers and students at Brighton High School have designed a microgravity growth chamber to investigate the phototropic response of radish seedlings.

PURPOSE

The purpose for Brighton High School's involvement in the Getaway Special Program is twofold. First, we want to provide an opportunity for students to learn the scientific process by allowing them to design and conduct an experiment for flight on the shuttle. The experiment does not need to be unique nor the idea of one individual, but can be a team effort. Our emphasis is to stimulate interest in scientific investigation through hands-on involvement. Second, since more information about phototropic response in microgravity is needed, we could make a scientific contribution by designing an experiment which might add to that body of knowledge. We propose to build a functional growth chamber which will provide an environment conducive to germination and growth of plants and to investigate phototropic stimulation to determine if it is adequate to influence directional orientation in the growth of plant seedlings in a microgravity environment.

EXPERIMENTAL DESIGN

Due to their location in the payload bay, Getaway Special cannisters are exposed to extremes of the space environment. Depending on the experimenters' requirements, various options are available. The cannister may be sealed to maintain one atmosphere of pressure or vented to attain the vacuum of space. An opaque or transparent lid may be used at present, and the option of an opening lid is planned. All cannisters are covered with an insulating protective outer layer. For our flight, we chose an opaque lid and a dry nitrogen atmosphere at sea level pressure.

The two and one half cubic feet of space in the cannister was apportioned into three parts. Our share was a space four inches in depth by twenty inches across. The experiment was enclosed in a one-fourth inch thick, hexagonal, fiberglass-foam spacepak nineteen inches across corners. It consists of a growth chamber and germination tray, a water reservoir and solenoid valve, a florescent light, a Minolta X700 camera with programmable back, a 50mm macro lens and flash, a battery pack, and a computer controller. (see figure 1)

The growth chamber and germination tray are constructed from one-fourth inch plexiglass and painted inside with flat black epoxy paint to reduce internal reflection. To maintain one atmosphere of air, the lid seals completely. Its geometry evolved from a need for the camera to see across the entire face of the germination tray. Felt strips were glued to the inside to prevent creeping of excess water toward the transparent camera window. The germination tray contains a diaper liner medium on which seeds germinate. This medium was chosen for its ability to absorb water rapidly and hold it. A mesh placed over the individual seed windows prevents seeds from vibrating out at launch.

Surgical tubing was used as a reservoir for water because it could act as a container and pump to force water into the germination tray. Release of the water is controlled by an electrical solenoid valve. Tests determined the exact amount of water required to saturate the diaper material without leaking any into the growth chamber.

The florescent light apparatus used for photostimulation was obtained from a hand held battery powered light and operates adequately on four volts. Six ten amp Gates X cells provide current to operate the lamp.

Data acquisition and storage is provided primarily by a Minolta X 700 camera which is programmed to shoot a picture every two hours for thirty-six exposures. In addition, two temperature sensors and one light sensor located in the walls of the growth chamber provide temperature and illumination data. A computer-controller designed by Sawat Tantiphanwadi, of Utah State University, provides 8 K command and 34 K data storage capability. All systems were chosen for minimal power requirement due to limited battery capacity. The computer runs on six volts, the solenoid six volts, and the lamp on four.

EXPERIMENTAL PROCEDURE

After construction and trial runs, Getaway Special experiments are taken to Kennedy Space Center to be placed in a Getaway cannister. NASA engineers perform safety and operational checks, the cannisters are purged with dry nitrogen and readied for installation in the orbiter. At a predetermined time during the space flight, depending on shuttle and payload requirements, the astronauts send a signal to the Getaway Special latching relay which actuates the experiments.

When the latching relay actuates the computer-controller in the Brighton High School experiment, the sequence is as follows:

1. The solenoid valve opens to allow water to flow into the germination tray.

2. Seeds germinate in the dark for fifty hours.

3. At fifty hours, commands are given to turn on the camera and light.

4. The camera takes one exposure every two hours.

5. The light operates for forty-six hours.

6. At a total elapsed time of ninety-six hours, the controller shuts the system down.

7. During the entire ninety-six hours, the computer takes a reading of temperature and illumination each thirty minutes and stores it.

8. Within seventy-two hours after landing, we are able to pick up our experiment.

DISCUSSION

When we opened our experiment, we determined that it had not been activated. A malfunctioning latching relay had stuck and caused the battery power level to reduce to a point that, when astronauts gave the signal to start the experiment, it would not function.

Although the experiment did not activate, a major educational goal had been achieved. Students had taken basic concepts of geotropism and phototropism and designed around them a plant growth experiment to determine their effect in a microgravity environment. They further demonstrated a high degree of innovativeness in using off-the-shelf materials to construct a completely self-contained and self-controlled experiment. The experiment was run through its entire cycle many times and worked satisfactorily every time. Each subsystem was designed and tested thoroughly before the final project was integrated. Germination studies gave valuable experience to those students who patiently grew many types of seeds to determine the fastest germinating and most phototropically sensitive variety. Plans are being made and preliminary arrangements made to refly the experiment on STS 19 (51 A) in late October of 1984. The project will fly alone and will be equipped with a new space rated activating relay.

CONCLUSION

The prospect of extended spaceflight calls attention to the necessity for growing food in space. Preliminary experimentation has been conducted to determine growth characteristics of plants in weightlessness and results have been varied. A major conclusion is that more work remains to be done toward understanding the mechanisms of plant orientation in microgravity. Space research, which used to be limited to a few leading scientists, is now accessable to all levels of the educational community through the Getaway Special Program. Students are able to apply basic principles learned in class to exciting, mind expanding research projects.

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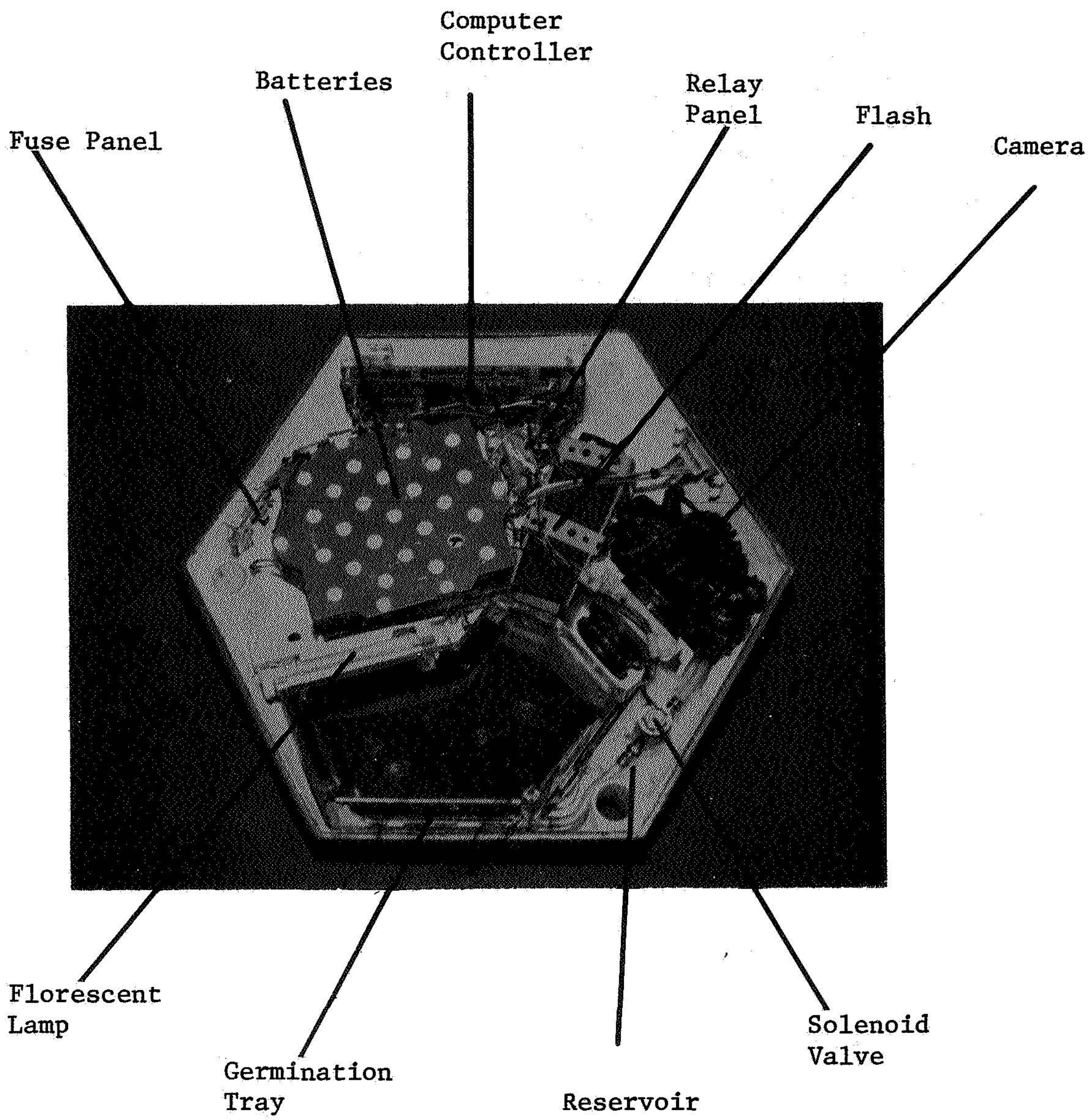
Figure 1



Top view of experiment showing growth chamber without cover. Spacepak construction is fiberglass-foam-fiberglass sandwich producing high strength and rigidity with minimum weight.

LABORATORY DISCHARGE STUDIES OF A 6 V ALKALINE LANTERN-TYPE BATTERY EVEREADY ENERGIZER NO. 528, UNDER VARIOUS AMBIENT TEMPERATURES (-15°C AND + 22°C) AND LOADS (30 Ω AND 60 Ω)

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ABSTRACT

Using a dual channel chart recorder, the voltages of two Eveready No. 528 batteries--one the test battery, the other the control battery--were simultaneously recorded as they were discharged across 30 Ω loads. The test battery was initially put in a freezer at -15 ± 3°C. After its voltage had fallen to .6 V, it was brought back out into the room at 22 ± 3°C. A second run was made with 60 Ω loads.

Assuming a 3.0 V cut-off, the total energy output of the test battery at -15°C was 26 WHr @ 30 Ω and 35 WHr @ 60 Ω, and the corresponding numbers for the control battery at 22°C were 91 WHr and 100 WHr. When the test battery was subsequently allowed to warm up, the voltage rose above 4 V and the total energy output rose to 80 WHr @ 30 Ω and 82 WHR @ 60 Ω.

INTRODUCTION

During the past three years, while getting our experiments ready, we have spent a considerable amount of time looking for a battery suitable for our payload. Most recently, our attention has been focused on a 6 V alkaline lantern-type battery, the Eveready Energizer No. 528 (.850 kg, 434 cm^3).

Our interest in alkalines was motivated primarily by their generally acknowledged excellent shelf-life, high energy density and minimal hazzard potential. We picked the 6 V lantern-type battery because our power requirements called for the equivalent of many D-size alkaline cells. The 6 V lantern-type with its 4 F-size cells--each F cell being approximately 50% bigger than a D cell--and its rugged construction would thus cut down greatly on the number of electrical connections that would have to be checked out every time these primary batteries had to be replaced. The Eveready brand was chosen because Eveready D-size alkalines had already been successfully used by another GAS user.

In studying the Eveready No. 528, we attempted to answer the following questions:

1. What do the discharge curve and total energy output look like?
2. How are these two characteristics affected by different temperatures and different load levels?

We were able to secure from Eveready a handbook[1] and some data sheets on alkalines. Unfortunately, only very general data was found for the F cells and the 528.

APPARATUS

The setup used is seen in Fig. 1. It consists of a dual channel chart recorder, two decade resistance boxes, two batteries--one the test battery, the other the control battery--and a freezer.

Not shown in the figure is a second chart recorder and two thermocouples used to monitor ambient temperatures of the test and control batteries.

PROCEDURE

Two batteries were chosen at random from an initial collection of a 20 Ω donated by Union Carbide. Both decade resistance boxes were adjusted for 30.0 Ω and checked with a digital multimeter. The control battery was left on the laboratory bench at 22 ± 3°C. The test battery was placed in the freezer at -15 ± 3°C. Both batteries were simultaneously connected to their resistance boxes and their voltages were monitored by digital multimeters and recorded by a calibrated chart recorder set a 1 cm/hr.

When the test battery voltage reached .6 V, it was removed from the freezer and placed alongside the control battery, where the discharge was allowed to proceed uninterrupted. The recording of voltages continued until both were below .6 V.

A second run was then made using the same procedures with two fresh batteries and new load resistances of 60.0 Ω.

RESULTS AND DISCUSSION

The raw data resulting from this study was in the form of curve traces on chart recorder paper. Even at the slowest selectable speed available (1 cm/hr) the output for the 30 Ω discharge was 11 feet long while the output for the 60 Ω discharge was 19 feet long. In order to be able to easily see the major patterns in the discharge curves, the results have been replotted using a highly compressed time scale (Fig. 2). The replotted curves accurately represent the original curves with one exception. Namely, in the original curves below 3.0 V, there were occasional small bumps (up to 2 hrs in duration and .2 V high) and numerous spikes (less than 1 sec in duration and up to .5 V high). The spikes were most abundant in the control battery. Wherever the bumps and spikes were found time averages have been used to simplify the replotting. Above 3.0 V the original curves were all very smooth and thus the replotted curves are very realistic.

[1] Eveready Battery Engineering Data, Union Carbide, Vol. II, 1982.

The first major feature that can be readily seen in the discharge curves of Fig. 2 is the significantly quicker drop-off rate for the test battery at -15°C. At 30 Ω with a 3.0 V cut-off the control battery lasted for about 6 days, whereas the test battery lasted approximately 2 days. At 60 Ω the same general pattern is seen with the number of days being approximately 13 days and 6 days respectively.

The second, and definitely most surprising, feature seen in the discharge curves of both runs is the rise in the voltage of the test battery from .6 V to over 4.0 V when it was removed from the freezer and put along side the control battery.

Some numerical analysis of the chart recorder data was also done. For each run, a convenient sampling time interval was chosen. For the 30 Ω run quarter days were used; for the 60 Ω run half-days. For each time interval, the average voltage was determined from the chart recorder output. If the discharge was linear over the interval, mid points were used; if the discharge was non-linear, the interval was broken down further into a subset of smaller intervals from which an overall average voltage was calculated. Using the average voltages found, further calculations were done for each interval to give average current, average power and average energy output in amp-hours and watt-hours. In addition, a running total of amp-hours and watt-hours was kept. The results are given in Tables 1, 2, 3 and 4 and summarized in Table 5.

Table 5 shows how temperature affects the 528 Energizer. Again using a 3.0 Ω cut-off, the total energy output of the test battery at -15°C was 26 WHr @ 30 Ω and 35 WHr @ 60 Ω. The corresponding numbers from the control battery at 22°C were 91 WHr and 100 WHr. In addition, when the test battery was subsequently allowed to warm up to 22°C, the total energy output recovered to 80 WHr @ 30 Ω and 82 WHr @ 60 Ω.

CONCLUSION

The performance of the Eveready No. 528:

1. Is severely hurt at the low temperatures used in this study.
2. Improves significantly if the battery is subsequently warmed back up.
3. Is, as expected, greatest with the slowest discharge rate.

ACKNOWLEDGEMENTS

We are grateful to Mr. Wayne Crigler, Visiting Professor of Electrical Engineering from Bell Labs, for helping direct this study. We would also like to thank the students, Mr. Brian Burnette, Mr. Derrick Hood and Ms. Tonya Crawford, who worked so diligently collecting and analyzing this data.

FIGURE 1. BATTERY TESTING LAYOUT

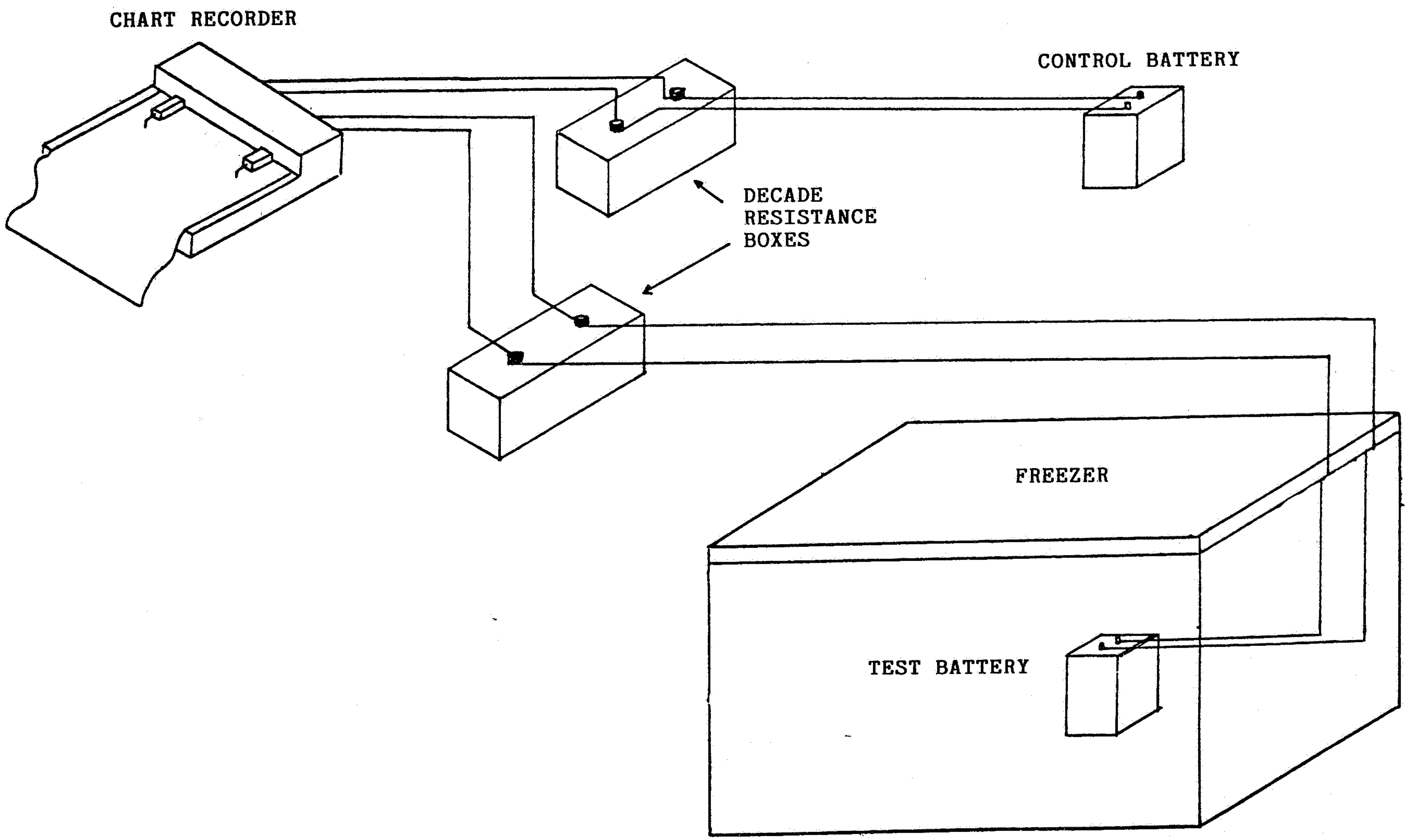


FIGURE 2. REPLOTTED DISCHARGE CURVES: Voltage (Volts) vs Elapsed Time (Days)

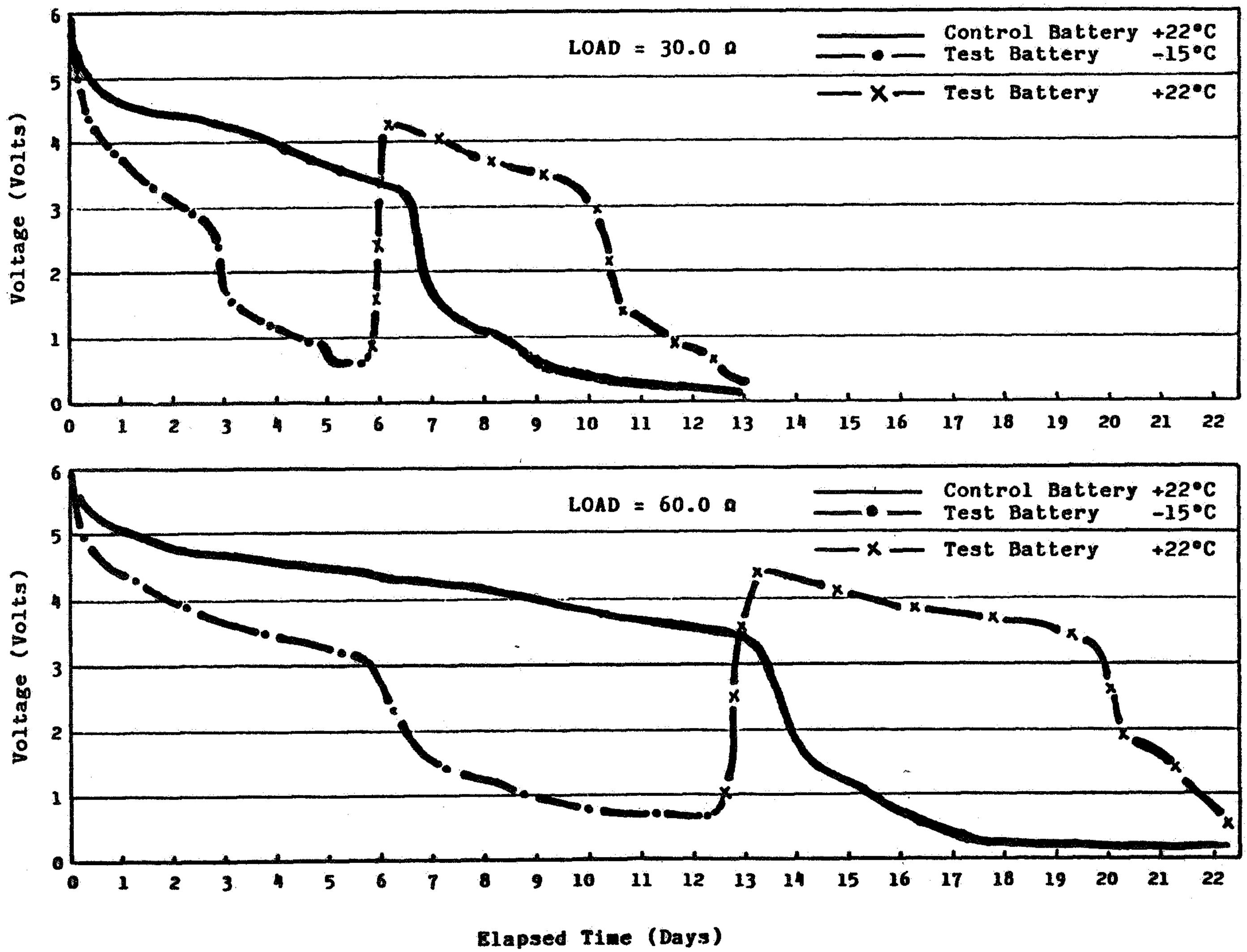


Table 1. Test Battery

Load = 30.0 Ω   1T = 1/4 Day

T	AVG.(V)	AVG.(I)	AVG.(P)	A.H./ T	CUMM.AH	W.H./ T	CUMM.WH
1	4.97V	0.166A	0.823W	0.994AH	0.994	4.940WH	4.940
2	4.38V	0.146A	0.639W	0.876AH	1.870	3.837WH	8.777
3	4.08V	0.136A	0.555W	0.816AH	2.686	3.329WH	12.106
4	3.85V	0.128A	0.494W	0.770AH	3.456	2.965WH	15.071
5	3.63V	0.121A	0.439W	0.726AH	4.182	2.635WH	17.706
6	3.46V	0.115A	0.399W	0.692AH	4.874	2.394WH	20.101
7	3.33V	0.111A	0.370W	0.666AH	5.540	2.218WH	22.318
8	3.20V	0.107A	0.341W	0.640AH	6.180	2.048WH	24.366
9	3.05V	0.102A	0.310W	0.610AH	6.790	1.861WH	26.227
10	2.92V	0.097A	0.284W	0.584AH	7.374	1.705WH	27.932
11	2.78V	0.093A	0.258W	0.556AH	7.930	1.546WH	29.478
12	2.39V	0.080A	0.190W	0.478AH	8.408	1.142WH	30.620
13	1.55V	0.052A	0.080W	0.310AH	8.718	0.481WH	31.101
14	1.45V	0.048A	0.070W	0.290AH	9.008	0.421WH	31.521
15	1.32V	0.044A	0.058W	0.264AH	9.272	0.348WH	31.870
16	1.18V	0.039A	0.046W	0.236AH	9.508	0.278WH	32.148
17	1.06V	0.035A	0.037W	0.212AH	9.720	0.225WH	32.373
18	1.00V	0.033A	0.033W	0.200AH	9.920	0.200WH	32.573
19	0.94V	0.031A	0.029W	0.188AH	10.108	0.177WH	32.750
20	0.91V	0.030A	0.028W	0.182AH	10.290	0.166WH	32.915
21	0.60V	0.020A	0.012W	0.120AH	10.410	0.072WH	32.987
22	0.60V	0.020A	0.012W	0.120AH	10.530	0.072WH	33.059
23	0.60V	0.020A	0.012W	0.120AH	10.650	0.072WH	33.131
24	1.55V	0.052A	0.080W	0.310AH	10.960	0.481WH	33.612
25	4.25V	0.142A	0.602W	0.850AH	11.810	3.613WH	37.224
26	4.25V	0.142A	0.602W	0.850AH	12.660	3.613WH	40.837
27	4.18V	0.139A	0.582W	0.836AH	13.496	3.494WH	44.331
28	4.11V	0.137A	0.563W	0.822AH	14.318	3.378WH	47.710
29	4.03V	0.134A	0.541W	0.806AH	15.124	3.248WH	50.958
30	3.91V	0.130A	0.510W	0.782AH	15.906	3.058WH	54.015
31	3.85V	0.128A	0.494W	0.770AH	16.676	2.963WH	56.980
32	3.77V	0.126A	0.474W	0.754AH	17.430	2.843WH	59.823
33	3.70V	0.123A	0.456W	0.740AH	18.170	2.738WH	62.561
34	3.65V	0.122A	0.444W	0.730AH	18.900	2.665WH	65.225
35	3.60V	0.120A	0.432W	0.720AH	19.620	2.592WH	67.817
36	3.55V	0.118A	0.420W	0.710AH	20.330	2.521WH	70.338
37	3.50V	0.117A	0.408W	0.700AH	21.030	2.450WH	72.788
38	3.45V	0.115A	0.397W	0.690AH	21.720	2.380WH	75.168
39	3.35V	0.112A	0.374W	0.670AH	22.390	2.245WH	77.413
40	3.20V	0.107A	0.341W	0.640AH	23.030	2.048WH	79.461
41	2.95V	0.098A	0.290W	0.590AH	23.620	1.740WH	81.201
42	2.15V	0.072A	0.154W	0.430AH	24.050	0.925WH	82.126
43	1.40V	0.047A	0.065W	0.280AH	24.330	0.392WH	82.518
44	1.38V	0.046A	0.063W	0.276AH	24.606	0.381WH	82.898
45	1.24V	0.041A	0.051W	0.248AH	24.854	0.308WH	83.206
46	1.08V	0.036A	0.039W	0.216AH	25.070	0.233WH	83.439
47	0.91V	0.030A	0.028W	0.182AH	25.252	0.166WH	83.605
48	0.84V	0.028A	0.024W	0.168AH	25.420	0.141WH	83.746
49	0.75V	0.025A	0.019W	0.150AH	25.570	0.112WH	83.858
50	0.65V	0.022A	0.014W	0.130AH	25.700	0.085WH	83.943
51	0.35V	0.012A	0.004W	0.070AH	25.770	0.025WH	83.967
52	0.30V	0.010A	0.003W	0.060AH	25.830	0.018WH	83.985

Table 2. Control Battery

Load = 30.0 Ω   1T = 1/4 Day

T	AVG.(V)	AVG.(I)	AVG.(P)	A.H./ T	CUMM.AH	W.H./ T	CUMM.WH
1	5.35V	0.178A	0.954W	1.070AH	1.070	5.725WH	5.725
2	5.02V	0.167A	0.840W	1.004AH	2.074	5.040WH	10.765
3	4.81V	0.160A	0.771W	0.962AH	3.036	4.627WH	15.392
4	4.70V	0.157A	0.736W	0.940AH	3.976	4.418WH	19.810
5	4.60V	0.153A	0.705W	0.920AH	4.896	4.232WH	24.042
6	4.55V	0.152A	0.690W	0.910AH	5.806	4.141WH	28.182
7	4.50V	0.150A	0.675W	0.900AH	6.706	4.050WH	32.232
8	4.47V	0.149A	0.666W	0.894AH	7.600	3.996WH	36.228
9	4.42V	0.147A	0.651W	0.884AH	8.484	3.907WH	40.136
10	4.38V	0.146A	0.639W	0.876AH	9.360	3.837WH	43.973
11	4.31V	0.144A	0.619W	0.862AH	10.222	3.715WH	47.688
12	4.27V	0.142A	0.608W	0.854AH	11.076	3.647WH	51.334
13	4.25V	0.142A	0.602W	0.850AH	11.926	3.613WH	54.947
14	4.18V	0.139A	0.582W	0.836AH	12.762	3.494WH	58.441
15	4.10V	0.137A	0.560W	0.820AH	13.582	3.362WH	61.803
16	4.05V	0.135A	0.547W	0.810AH	14.392	3.281WH	65.084
17	3.92V	0.131A	0.512W	0.784AH	15.176	3.073WH	68.157
18	3.83V	0.128A	0.489W	0.766AH	15.942	2.934WH	71.091
19	3.75V	0.125A	0.469W	0.750AH	16.692	2.813WH	73.903
20	3.68V	0.123A	0.451W	0.736AH	17.428	2.708WH	76.612
21	3.60V	0.120A	0.432W	0.720AH	18.148	2.592WH	79.204
22	3.54V	0.118A	0.418W	0.708AH	18.856	2.506WH	81.710
23	3.48V	0.116A	0.404W	0.696AH	19.552	2.422WH	84.132
24	3.40V	0.113A	0.385W	0.680AH	20.232	2.312WH	86.444
25	3.32V	0.111A	0.367W	0.664AH	20.896	2.204WH	88.649
26	3.15V	0.105A	0.331W	0.630AH	21.526	1.985WH	90.633
27	2.89V	0.096A	0.278W	0.578AH	22.104	1.670WH	92.304
28	1.81V	0.060A	0.109W	0.362AH	22.466	0.655WH	92.959
29	1.50V	0.050A	0.075W	0.300AH	22.766	0.450WH	93.409
30	1.38V	0.046A	0.063W	0.276AH	23.042	0.381WH	93.790
31	1.25V	0.042A	0.052W	0.250AH	23.292	0.313WH	94.102
32	1.10V	0.037A	0.040W	0.220AH	23.512	0.242WH	94.344
33	1.10V	0.037A	0.040W	0.220AH	23.732	0.242WH	94.586
34	1.00V	0.033A	0.033W	0.200AH	23.932	0.200WH	94.786
35	0.80V	0.027A	0.021W	0.160AH	24.092	0.128WH	94.914
36	0.75V	0.025A	0.019W	0.150AH	24.242	0.112WH	95.027
37	0.53V	0.018A	0.009W	0.106AH	24.348	0.056WH	95.083
38	0.50V	0.017A	0.008W	0.100AH	24.448	0.050WH	95.133
39	0.45V	0.015A	0.007W	0.090AH	24.538	0.041WH	95.174
40	0.45V	0.015A	0.007W	0.090AH	24.628	0.041WH	95.214
41	0.40V	0.013A	0.005W	0.080AH	24.708	0.032WH	95.246
42	0.35V	0.012A	0.004W	0.070AH	24.778	0.025WH	95.271
43	0.33V	0.011A	0.004W	0.066AH	24.844	0.022WH	95.292
44	0.25V	0.008A	0.002W	0.050AH	24.894	0.012WH	95.305
45	0.25V	0.008A	0.002W	0.050AH	24.944	0.012WH	95.317
46	0.30V	0.010A	0.003W	0.060AH	25.004	0.018WH	95.335
47	0.25V	0.008A	0.002W	0.050AH	25.054	0.012WH	95.348
48	0.20V	0.007A	0.001W	0.040AH	25.094	0.008WH	95.356
49	0.20V	0.007A	0.001W	0.040AH	25.134	0.008WH	95.364
50	0.20V	0.007A	0.001W	0.040AH	25.174	0.008WH	95.372
51	0.15V	0.005A	0.001W	0.030AH	25.204	0.004WH	95.376
52	0.10V	0.003A	0.000W	0.020AH	25.224	0.002WH	95.378

Table 3. Test Battery

Load = 60.0 Ω   1T = 1/2 Day

T	AVG.(V)	AVG.(I)	AVG.(P)	A.H./ T	CUMM.AH	W.H./ T	CUMM.WH
1	4.95V	0.082A	0.408W	0.990AH	0.990	4.900WH	4.900
2	4.50V	0.075A	0.338W	0.900AH	1.890	4.050WH	8.951
3	4.30V	0.072A	0.308W	0.860AH	2.750	3.698WH	12.649
4	4.05V	0.067A	0.273W	0.810AH	3.560	3.281WH	15.929
5	3.90V	0.065A	0.254W	0.780AH	4.340	3.042WH	18.971
6	3.70V	0.062A	0.228W	0.740AH	5.080	2.738WH	21.709
7	3.60V	0.060A	0.216W	0.720AH	5.800	2.592WH	24.301
8	3.50V	0.058A	0.204W	0.700AH	6.500	2.450WH	26.751
9	3.40V	0.057A	0.193W	0.680AH	7.180	2.312WH	29.063
10	3.30V	0.055A	0.182W	0.660AH	7.840	2.178WH	31.241
11	3.20V	0.053A	0.171W	0.640AH	8.480	2.048WH	33.289
12	3.05V	0.051A	0.155W	0.610AH	9.090	1.861WH	35.149
13	2.30V	0.038A	0.088W	0.460AH	9.550	1.058WH	36.207
14	1.65V	0.028A	0.045W	0.330AH	9.880	0.545WH	36.752
15	1.40V	0.023A	0.033W	0.280AH	10.160	0.392WH	37.144
16	1.30V	0.022A	0.028W	0.260AH	10.420	0.338WH	37.482
17	1.15V	0.019A	0.022W	0.230AH	10.650	0.265WH	37.747
18	1.00V	0.017A	0.017W	0.200AH	10.850	0.200WH	37.946
19	0.90V	0.015A	0.014W	0.180AH	11.030	0.162WH	38.109
20	0.80V	0.013A	0.011W	0.160AH	11.190	0.128WH	38.236
21	0.78V	0.013A	0.010W	0.156AH	11.346	0.122WH	38.358
22	0.70V	0.012A	0.008W	0.140AH	11.486	0.098WH	38.456
23	0.70V	0.012A	0.008W	0.140AH	11.626	0.098WH	38.554
24	0.68V	0.011A	0.008W	0.136AH	11.762	0.092WH	38.647
25	0.65V	0.011A	0.007W	0.130AH	11.892	0.085WH	38.731
26	2.50V	0.042A	0.104W	0.500AH	12.392	1.250WH	39.981
27	4.40V	0.073A	0.323W	0.880AH	13.272	3.872WH	43.853
28	4.30V	0.072A	0.308W	0.860AH	14.132	3.698WH	47.551
29	4.23V	0.071A	0.298W	0.846AH	14.978	3.579WH	51.130
30	4.10V	0.068A	0.280W	0.820AH	15.798	3.362WH	54.492
31	4.00V	0.067A	0.267W	0.800AH	16.598	3.200WH	57.692
32	3.95V	0.066A	0.260W	0.790AH	17.388	3.120WH	60.812
33	3.85V	0.064A	0.247W	0.770AH	18.158	2.965WH	63.777
34	3.80V	0.063A	0.241W	0.760AH	18.918	2.888WH	66.665
35	3.75V	0.063A	0.234W	0.750AH	19.668	2.813WH	69.477
36	3.70V	0.062A	0.228W	0.740AH	20.408	2.738WH	72.215
37	3.62V	0.060A	0.218W	0.724AH	21.132	2.621WH	74.836
38	3.60V	0.060A	0.216W	0.720AH	21.852	2.592WH	77.428
39	3.45V	0.057A	0.198W	0.690AH	22.542	2.380WH	79.809
40	3.25V	0.054A	0.176W	0.650AH	23.192	2.113WH	81.921
41	1.91V	0.032A	0.061W	0.382AH	23.574	0.730WH	82.651
42	1.79V	0.030A	0.053W	0.358AH	23.932	0.641WH	83.292
43	1.40V	0.023A	0.033W	0.280AH	24.212	0.392WH	83.684
44	0.98V	0.016A	0.016W	0.196AH	24.408	0.192WH	83.876
45	0.55V	0.009A	0.005W	0.110AH	24.518	0.061WH	83.936
46	0.53V	0.009A	0.005W	0.106AH	24.624	0.056WH	83.992

Table 4. Control Battery

Load = 60.0 Ω   1T = 1/2 Day

T	AVG.(V)	AVG.(I)	AVG.(P)	A.H./ T	CUMM.AH	W.H./ T	CUMM.WH
1	5.45V	0.091A	0.495W	1.090AH	1.090	5.941WH	5.941
2	5.15V	0.086A	0.442W	1.030AH	2.120	5.304WH	11.245
3	5.00V	0.083A	0.417W	1.000AH	3.120	5.000WH	16.245
4	4.85V	0.081A	0.392W	0.970AH	4.090	4.705WH	20.950
5	4.75V	0.079A	0.376W	0.950AH	5.040	4.512WH	25.462
6	4.70V	0.078A	0.368W	0.940AH	5.980	4.418WH	29.880
7	4.68V	0.078A	0.365W	0.936AH	6.916	4.380WH	34.260
8	4.60V	0.077A	0.353W	0.920AH	7.836	4.232WH	38.492
9	4.57V	0.076A	0.348W	0.914AH	8.750	4.177WH	42.669
10	4.50V	0.075A	0.338W	0.900AH	9.650	4.050WH	46.719
11	4.46V	0.074A	0.332W	0.892AH	10.542	3.978WH	50.698
12	4.40V	0.073A	0.323W	0.880AH	11.422	3.872WH	54.570
13	4.30V	0.072A	0.308W	0.860AH	12.282	3.698WH	58.268
14	4.30V	0.072A	0.308W	0.860AH	13.142	3.698WH	61.966
15	4.20V	0.070A	0.294W	0.840AH	13.982	3.528WH	65.494
16	4.20V	0.070A	0.294W	0.840AH	14.822	3.528WH	69.022
17	4.10V	0.068A	0.280W	0.820AH	15.642	3.362WH	72.384
18	4.03V	0.067A	0.271W	0.806AH	16.448	3.248WH	75.632
19	3.96V	0.066A	0.261W	0.792AH	17.240	3.136WH	78.768
20	3.85V	0.064A	0.247W	0.770AH	18.010	2.965WH	81.733
21	3.79V	0.063A	0.239W	0.758AH	18.768	2.873WH	84.606
22	3.70V	0.062A	0.228W	0.740AH	19.508	2.738WH	87.344
23	3.65V	0.061A	0.222W	0.730AH	20.238	2.664WH	90.008
24	3.60V	0.060A	0.216W	0.720AH	20.958	2.592WH	92.600
25	3.50V	0.058A	0.204W	0.700AH	21.658	2.450WH	95.050
26	3.45V	0.057A	0.198W	0.690AH	22.348	2.380WH	97.431
27	3.25V	0.054A	0.176W	0.650AH	22.998	2.113WH	99.543
28	2.30V	0.038A	0.088W	0.460AH	23.458	1.058WH	100.601
29	1.45V	0.024A	0.035W	0.290AH	23.748	0.421WH	101.022
30	1.30V	0.022A	0.028W	0.260AH	24.008	0.338WH	101.360
31	1.10V	0.018A	0.020W	0.220AH	24.228	0.242WH	101.602
32	0.80V	0.013A	0.011W	0.160AH	24.388	0.128WH	101.730
33	0.60V	0.010A	0.006W	0.120AH	24.508	0.072WH	101.802
34	0.70V	0.012A	0.008W	0.140AH	24.648	0.098WH	101.900
35	0.30V	0.005A	0.001W	0.060AH	24.708	0.018WH	101.916
36	0.27V	0.004A	0.001W	0.054AH	24.762	0.015WH	101.932
37	0.25V	0.004A	0.001W	0.050AH	24.812	0.012WH	101.945
38	0.22V	0.004A	0.001W	0.044AH	24.856	0.010WH	101.954
39	0.22V	0.004A	0.001W	0.044AH	24.900	0.010WH	101.964
40	0.20V	0.003A	0.001W	0.040AH	24.940	0.008WH	101.972
41	0.20V	0.003A	0.001W	0.040AH	24.980	0.008WH	101.980
42	0.20V	0.003A	0.001W	0.040AH	25.020	0.008WH	101.988
43	0.19V	0.003A	0.001W	0.038AH	25.058	0.007WH	101.995
44	0.19V	0.003A	0.001W	0.038AH	25.096	0.007WH	102.002
45	0.19V	0.003A	0.001W	0.038AH	25.134	0.007WH	102.010
46	0.19V	0.003A	0.001W	0.038AH	25.172	0.007WH	102.017

Table 5. Summary

LOAD RESISTANCE = 30.0 Ω				LOAD RESISTANCE + 60.0 Ω			
TEST BATTERY		CONTROL BATTERY		TEST BATTERY		CONTROL BATTERY	
CONDITIONS	CUMULATIVE WATT-HRS	CONDITIONS	CUMULATIVE WATT-HRS	CONDITIONS	CUMULATIVE WATT-HRS	CONDITIONS	CUMULATIVE WATT-HRS
Freezer (3.0 V cut-off)	26	Room (3.0 V cut-off)	91	Freezer (3.0 V cut-off)	35	Room (3.0 V cut-off)	100
Freezer (.6 V cut-off)	33	Room (.6 V cut-off)	95	Freezer (.6 V cut-off	39	Room (.6 V cut-off	102
Room (3.0 V cut-off)	80			Room (3.0 V cut-off)	82		
Room (.6 V cut-off)	84			Room (.6 V cut-off)	84		

PROJECT EXPLORER: GET AWAY SPECIAL #007

by

Arthur J. Henderson, Jr.

GAS EXPERIMENTERS SYMPOSIUM AT GSFC

August 1-2, 1984

INTRODUCTION

PROJECT EXPLORER is a program that will fly student-developed experiments onboard the Space Shuttle in one of NASA's "Get-Away Special" (GAS) containers designated as G #007. The program is co-sponsored by the Alabama Space and Rocket Center, the Alabama-Mississippi Section of the American Institute of Aeronautics and Astronautics, Alabama A&M University and requires extensive support by the University of Alabama in Huntsville. Project Explorer is tentatively scheduled to fly on October 5, 1984, on STS-17 (41G). A unique feature of this GAS mission will demonstrate amateur radio transmissions to global ground stations in the English language.

In 1978, the co-sponsoring agencies undertook this project to encourage high school students to become involved in space-oriented engineering efforts. A brochure was distributed nationwide to high schools throughout the United States soliciting proposals by high school students. The captivating brochure read: "Students, Can You See Your Ideas in Space (?)". Over 150 proposals were submitted and thirteen students were selected. Only two of the original thirteen students remain. One additional student P.I. has been added on since the loss of the others in 1981.

The concept of the project is to design, develop, and fly selected student experiments on the Space Shuttle and to obtain scientific data on the unique conditions of space flight, especially in the area of low-gravity conditions.

Experiments No. 1, 2, and 3 use the micro-gravity of space flight to study the solidification of lead-antimony and aluminum-copper alloys, the germination of radish seeds, and the growth of potassium-tetracyanoplatinate hydrate crystals in an aqueous solution. Flight results will be compared with earth-based data.

Experiment No. 4 (the Marshall Amateur Radio Club Experiment - MARCE) features radio transmissions and will also provide timing for the start of all other experiments. A microprocessor will obtain real-time data from all experiments as well as temperature and pressure measurements within the GAS canister. These data will be transmitted on previously announced amateur radio frequencies after they have been converted into the "English language" by a digitalker for general reception.

OPERATIONAL SCENARIO

The G #007 Payload will require a duration of five (5) full days and a "turn-on" of the experimental package as early in the Space Shuttle mission as possible. Experiment No. 1: The Solidification of Alloys experiment will be started at a time when about 8 hours of very low "g" operations can be expected, such as during a sleep period for the crew. At that time, a signal from the GAS Operations Panel within the crew compartment will trigger the operation of this experiment. Subsequent operations will be started by built-in controls and do not need additional signals. Another period of low-gravity operations for a second solidification will occur about a day later.

Experiment No. 2: The Radish Seed Germination and Growth experiment must be initiated as soon as feasible, i.e., at about the time when the Shuttle reaches its orbit to obtain the longest possible growth period for the seeds. An orbital operation of at least five (5) days is needed for meaningful results. Operational control will be provided by MARCE: Upon the initial G #007 power-up, a relay will activate pump "A" to supply the water/fertilizer solution to the seeds. Upon power-down, approximately 120 hours later, another relay will activate pump "B" and freeze any further seed development by the application of buffered formaldehyde to the seeds.

Experiment No. 3: The Crystal Growth experiment will be activated when micro-gravity conditions exist. At the beginning of the first available low-g period lasting 4 hours or more, MARCE will power-up the electrolysis cell by a 1.3 V DC power supply, and crystals will start to form on the anode. A 35 mm camera and its electronic flash will have been activated at the same time, and will take a picture every 40 minutes. This experiment requires 24 hours for completion.

Experiment No. 4: The Marshall Amateru Radio Club Experiment (MARCE) will control all other experiments in accordance with individual requirements. The "ORBITER's ATONOMOUS PAYLOAD CONTROLLER (APC) provides AFT-Flight Deck control for experiments "turn-on" and "turn-off" and can also terminate all GAS operations if SAFETY NEEDS require such premature cessation of experimentation.

Three transmission cycles of 8 hours each are planned. A transmission cycle consists of a 30 second transmission every 4 minutes. When experiment #1 is active, transmissions will last about 45 seconds. The first 8-hour cycle will be activated at G #007 "turn-on". Second and third cycles will be started during the two experiment #1 operations.

DESCRIPTION

ALL experiment packages and/or their components are mounted on a rectangular mounting plate, which is in turn bolted to the rib of a round plate which is bolted directly to the GAS canister top lid.

Experiment No. 1 will solidify two alloy samples (Lead-Antimony and Aluminum-Copper) inside of an internally insulated aluminum cylinder (15" long and 6" diameter). It will house two small cylinders that will encompass two miniature furnaces 4½" H and 3/4" Diameter. (see Figure 1). The wall thickness of the cylinders are 1/16" thick. The melting furnaces are made of lava cores and are wrapped with Nichrome wire (spring coils). The alloy samples are centrally located in the middle of each furnace core and can be heated to temperatures of up to 700°C. The heat is generated by a 28 VDC electric current from a central power supply. Moreover, while the inner part of the small can is 700°C, the outer surface is only around 60°C.

The Data Acquisitions and Control Unit (DAQ2-K) exterior is also made of aluminum and it contains the experiment control system which supervises the two separate metallurgical experiments. Its primary functions include measuring temperatures of the experimental vessels, storing measured values for later recall, operating the two furnaces used in the experiment and sending experimental data to external telemetry equipment. The experiment control system has two modes of operation, normal and test. The normal mode is used during flight to run the experiments solely under control of the internal system. The test mode is used in the laboratory to insert and display the experiment's parameters.

During operation of the experiment, data is sent to the external telemetry equipment (located in Expt. #4) once a minute via a TTL serial data port in (Exp. #1). If the system is operating in the test mode, identical data is also routed to the RS232 port. Telemetry data consists of an identification of the mode currently executing the current time as maintained by the system and the measured values from all eight thermocouples. These messages are formatted on a computer as shown below and are terminated by a carriage return and line feed:

AA T=HHMM TC1=RR TC2=RR TC3=RR TC4=RR TC5=RR TC6=RR TC7=RR TC8=RR

Where AA is a two character abbreviation of the current mode, HH is the current hour in 24 hour format, MM is the current minute and RR is the actual reading - all in hexadecimal notation. This experiment will weigh less than 30 lbs.

MARCE will provide the signal to start the melting and solidification process of experiment No. 1 at a time when about 8 hours of very low "g" operations can be expected, such as during a sleep period for the crew. At that time, a signal from the GAS APC within the crew compartment will trigger the operation of this experiment. Subsequent operations are controlled automatically and do not need additional signals from the crew.

Experiment No. 2 will be conducted inside of an aluminum container. The radish seeds will be held in place by filter paper as the growth substrate. Gear-type pumps will initially deliver a water/fertilizer solution to the seeds, and at the end of the mission supply a buffered formeldehde solution to stop any further growth during descent and disassembly after return.

Operational control of the experiment will be provided by the MARCE radio experiment. One hour after initial G #007 power-up, a control relay will be closed for 30 seconds and thus activate pump "A" which supplies the water/fertilizer solution to the seeds. Prior to G #007 power-down (approximately 120 hours later) a second control relay will close for 30 seconds and thus activate pump "B", which supplies the buffered formaldehyde solution.

This experiment will require a temperature of 30°C plus/minus 10°C. Should temperatures inside the growth chamber go below 20°C, a small heater will be activated to maintain required temperatures. There will be no cooling provisions for temperatures above 40°C.

A turn-on signal as early in flight as possible is desired as well as an experiment operations time of 5 full days in orbit. Best available micro-gravity levels are desired, but 10.-3 g's is acceptable. This experiment will weigh less than 15 lbs.

Experiment No. 3 will be conducted in an electrolysis cell of 6 ml volume. The cell is made of plexiglas and fitted with two small platinum electrodes. An optical system consists of a 35 mm NIKON F-2 camera with a 50 mm close-up lens; camera auto-winder MD-3 with camera battery pack MB-1; and a small NIKON SB-E electronic flash. The battery pack holds 10 AA size batteries (15 V DC) and is used to power the camera. The electronic flash holds 4 AAA size (6 F DC) batteries. Operational control of the experiment consists of application of a 1.3 V DC precision reference supply to furnish the potential across the platinum electrodes for nucleation of crystal growth; camera operation will be synchronized with the flash to photograph the crystals at a rate of one exposure per four minutes for 24 hours. A thermistor is attached to the electrolytic cell to monitor the temperature fluctuations of the experiment's environment. The precision reference supply and a control timer will be furnished by MARCE. The experiment will weigh less than 10 lbs.

Experiment No. 4 provides power, control and on-board storage of G #007 experiments environmental data. MARCE will acquire these data for input to analog-to-digital converters through signal lines. A voice synthesizer Digitalker system will convert the experimental data into "ENGLISH LANGUAGE" and will modulate the transmitter

The weight of all MARCE equipment besides the battery will be about 10 pounds. A 25 pound surplus SPAR battery will provide power at 28 V DC and 20 amp-hrs.

SUPPORT STRUCTURE

The support structure for the G #007 experiments consists of two primary plates and four "bumper" assemblies. One of the primary plates is a round plate which mounts to the GAS canister top lid. This round plate has a machined rib along a diameter, to which the second rectangular plate is bolted. This rectangular plate divides the GAS canister volume in two equal halves along the longitudinal axis. The bottom of the rectangular plate, which supports all experiments, is supported by four "bumpers" contacting the inside of the canister. Two of these "bumpers" are mounted on the lower corners of the rectangular plate. The other two "bumpers" are mounted on "T" mounts perpendicular to the faces of the rectangular plate. (See Figures).

TECHNICAL LESSONS LEARNED

Even from the simplest of experimental ideas, there is much, much more than meets the eye. The main lesson learned was the complexity involved in preparing a simple GAS payload - in addition to the tons and tons of paper work. From the initial ideas, to the design and fabrication of all experiments, as well as integrating the four experiments into one functional package made the whole endeavor invaluable.

For experiment No. 1, the major problem was finding a way to monitor and store the experimental parameters during operation. This problem prompted the development of the DAQ2-K.

For experiment Nos. 2 and 3, the main problem was maintaining a constant temperature for an extended period of time. Miniature heaters were designed to facilitate this problem. In addition, for experiment No. 3, recording the crystal's growth was questionable until a modified 35 mm camera was acquired to compensate this essential requirement.

Experiment No. 4's major hurdle was obtaining approval to mount an external antenna on the outside of the GAS canister. Also, this problem was overcome.

Overall, PROJECT EXPLORER has come a long way from its initial beginning and has accomplished 90% of its original objectives.

ACKNOWLEDGEMENT

G #007 could not have been completed without the dedication and total commitment of the student P.I.'s and MARCE P.I. who all made gallant achievements in preparing their individual experiments. Also, thanks and appreciation go to the co-Directors, Project Manager, the Integration Team, and countless others who have contributed immensely in making this payload a huge success.

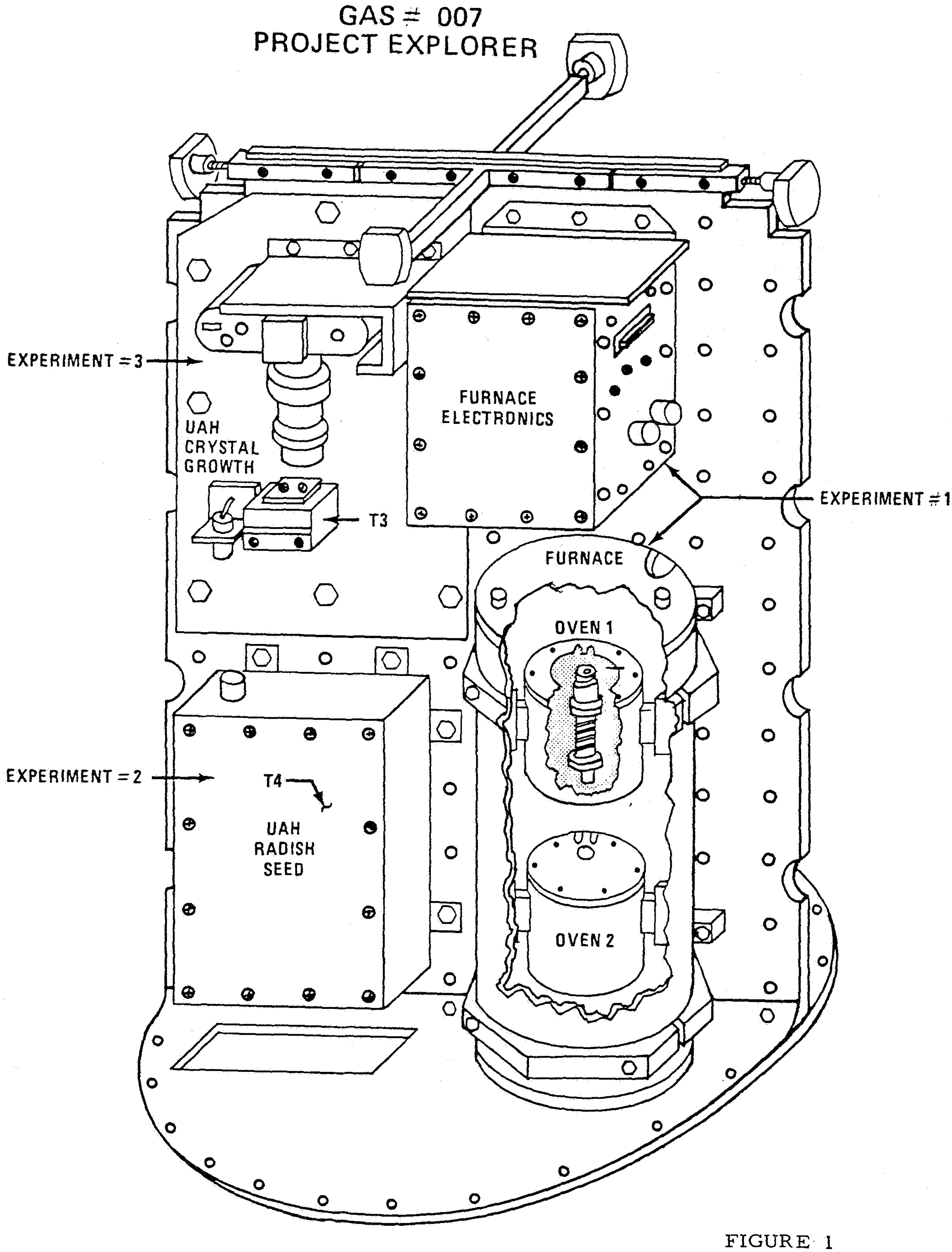
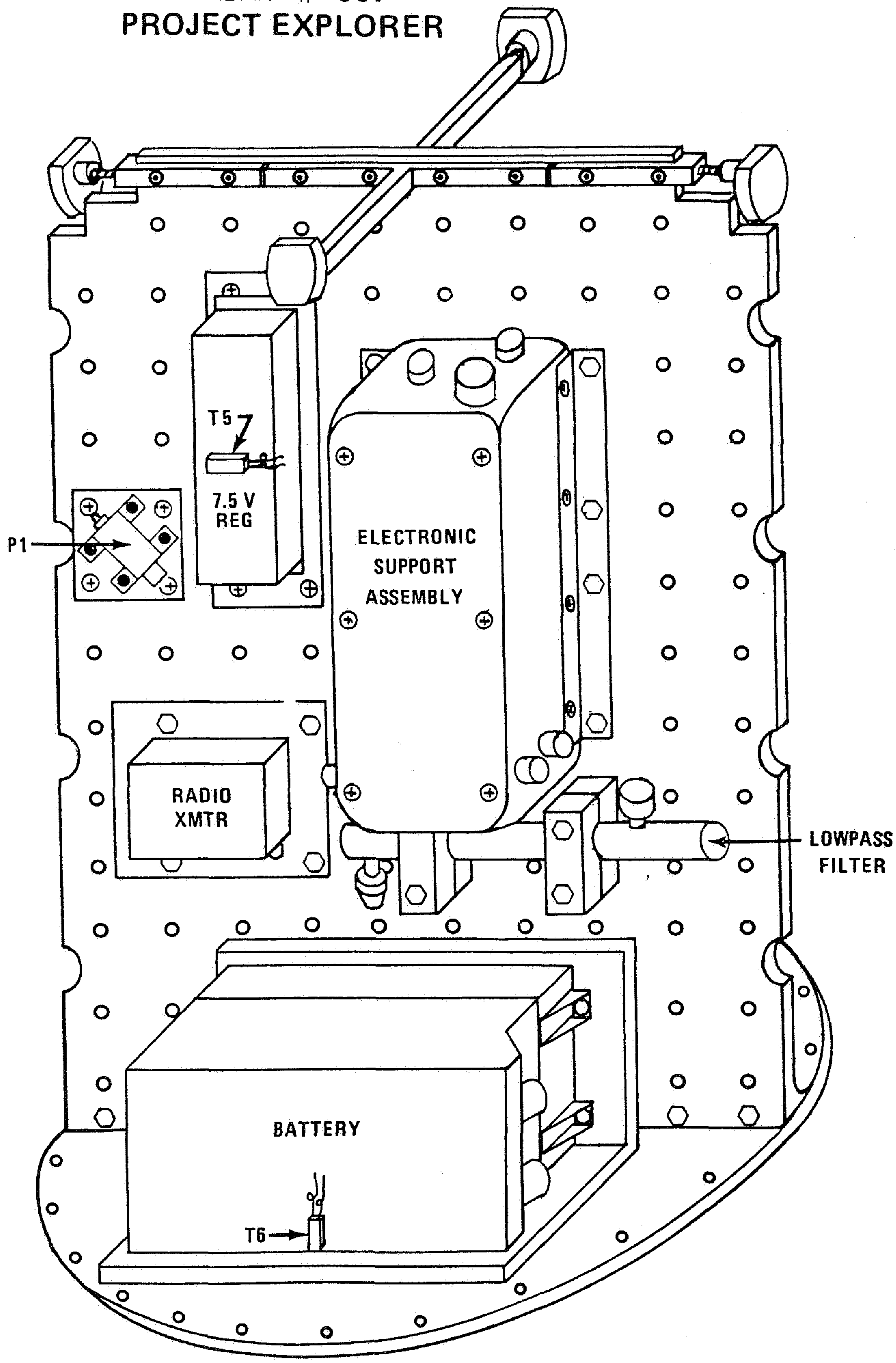

GAS ≠ 007
PROJECT EXPLORER
EXPERIMENT = 3
UAH
CRYSTAL
GROWTH
T3
FURNACE
ELECTRONICS
EXPERIMENT ≠ 1
FURNACE
OVEN 1
EXPERIMENT = 2
T4
UAH
RADISH
SEED
OVEN 2

FIGURE 1

GAS # 007
PROJECT EXPLORER



EXPERIMENT #4 FIGURE 2

G-38, 39 and 40

An Artist's Exploration of Space

Joseph W. McShane *
C. Daniel Coursen **

"Some say they see poetry in my painting: I see only science."
From the notebook of the pointillest painter Georges Seurat.

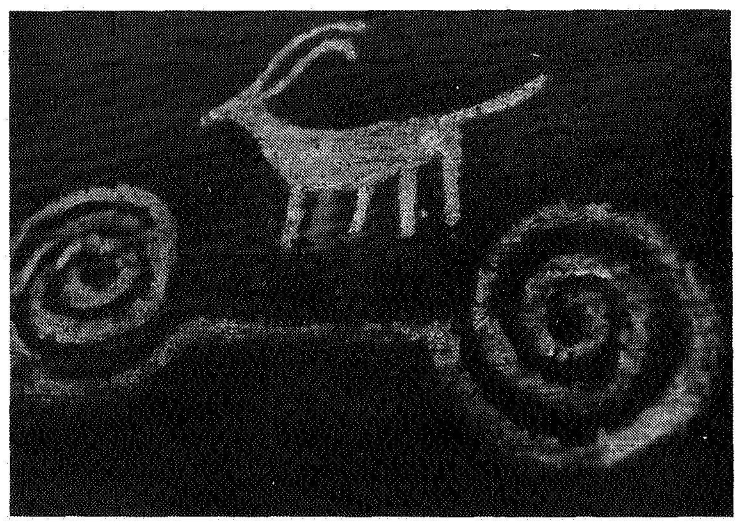
This paper is a tripartite exploration of (1) the human imagination in space, (2) a synopsis of the concepts expressed in Payloads G-38, 39 and 40 and (3) the systems of G-38 and technical lessons learned during the design and fabrication of the payload (sections 1 and 2 by Joseph W. McShane, section 3 by C. Daniel Coursen).

1

20,000 years ago, on the edge of the European ice sheet, in caves like Altamira in Spain, the visionary hunter/artist held brush in hand and sought understanding by creating an image of the animals that formed the basis of his culture. When that artist grasped the brush as an extension of his eye and hand he was using a tool on the cutting edge of his technology.

The computer on G-38 and the systems it interacts with are tools on the cutting edge of our technology. They form an extension of the artist's eye and hand as I seek to understand 20,000 years later the nature of the vacuum, weightlessness and scale of space that will become the basis of the next 20,000 years of man's future.

Anasazi pictograph, painted 1200 years ago.
Photographed in the Grand Gulch of the San Juan Basin, Utah by Charles Lyon.



The mathematician/philosopher Jacob Bronowski saw the cave painting as a sort of timelock. "For us, the cave paintings re-create the hunter's way

* Marshall-McShane, Prescott, Arizona
Sculptor/Payload Manager

** G.M. Vacuum Coating Laboratory, Newport Beach, California
Optical Design and Engineering/Payload Engineer

of life as a glimpse of history: we look through them into the past. But for the painter/hunter, I suggest, they were a peep-hole into the future: he looked ahead. In either direction, the cave paintings act as a kind of telescope tube of the imagination: they direct the mind from what is seen to what can be inferred or conjectured."

The analogy of a telescope of the imagination that Bronowski applied to the cave paintings also aptly applies to the sculptures that will be created by the technological experiments in space of payloads G-38, 39 and 40. For the first time since man first gazed at the stars and from an earth-bound, one-atmosphere, one-gravity perspective sought understanding of the unfathomable heavens through his art, the opportunity has been presented to make use of man's technology as an extension of the artist's eye and hand to venture forth directly into the vacuum and weightlessness of space, seeking understanding.

Until the opportunity was presented to work directly in space by the Small Self-Contained Payload Program, the artist has always been earth-bound, able to only create imaginary images of a space he could never know. The program offers the opportunity for the artist to develop and interact with a technology unique to space: to create new artistic concepts of space with new materials on a scale never before possible.

On a fall day in 1981, standing with astrophysicist Phillip Morrison at MIT's Steinbrenner Stadium, watching Japanese kites soar through the sky, Phillip said (and I quote as accurately as I remember), "The earth is flat. Please don't quote me out of context," he hurried on to say, "but the scale involved in the few kilometers distance between the bottom of the Mariana Trench and the top of Mt. Everest becomes relatively insignificant and flat when one looks to space and contemplates not only how far away the Andromeda Nebula is, but how may light years older the light reaching us from the far side is than that from the edge nearest to us. That is the scale man will have to come to terms with as he ventures off the face of the earth and into space."

Today, with certain significant exceptions, sculpture remains fastened to earth somewhere between Mt. Everest and the Mariana Trench and to interact with it one walks slowly around its base observing a form constructed in such a way as to support itself in a one-gravity environment.

2

The intent of payload G-39 is to explore space with sculptural concepts: creating art on a scale never befor accessible, using materials and processes in a way specific to, and possible only in, the vacuum and weightlessness of orbit.

For a number of years, in addition to solid sculpture, I have created a series of sculptures out of bubbles, free for brief moments to flow as a diaphanous form with the breeze. On earth, due to gravity, the largest size any of these sculptures have attained is less than three feet in diameter. I owe a special thank you to GAS pioneer Gilbert Moore for providing the inspiration that permits the extension of this sculpture series from earth to space.

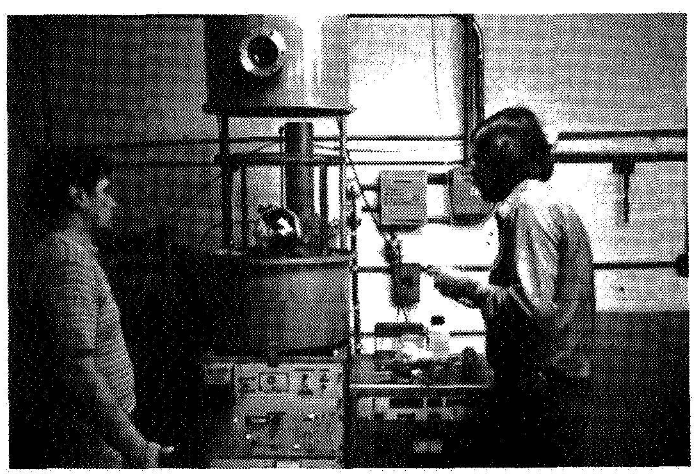
G-39 will expand on this series by ejecting a canister that, when safely away from the shuttle, will inflate bubbles in orbit out of a plastic material that will cure and harden in orbit. The absence of gravity will enable the bubbles to attain a size not possible on earth and clearly visible in the night sky from earth.

Looking to create a subtle reordering, of at least my own sense of scale and place, the sculpture becomes not the bubbles themselves, but conceptually the 30,000 mile circumference of the orbit they travel, creating a sculpture on a scale never before achieved. The earth will form the center of this art work and instead of walking around the sculpture, the orbit/sculpture would surround us and we will exist inside of, and look out at, it.

G-39 will be a peaceful celebration of man's venture into space, an art work possessed by no one and equally accessible to all.

As I first began to dream of using new technology to create art in space most thoughts centered on projects that would be ejected from the GAS can and placed in orbit, helping the mind make the transition from the one-gravity, one-atmosphere, horizon limited preconceptions that man has evolved with since his beginnings on an African plain, to the zero-gravity, vacuum, unlimited scale of space where man seems destined to venture. Each time I envisioned returning a payload to earth it became enmeshed in these innate earth-bound preconceptions. Since the operable lid was not scheduled for use on GAS containers until 1985, it became apparent that if I wanted to orbit an early experiment the payload would have to be processed in orbit and returned to earth. G-38 evolved to meet that condition.

G-38 is an interrelated group of nine glass spheres, blown for the experiment by the Schott Glass Works in Germany and modified for use in G-38. Eight of the spheres, ranging in size from 500ml to 3,000ml, will go into orbit as clear glass and while exposed to the unlimited vacuum of space be coated using two separate vacuum deposition techniques, with gold, platinum, aluminum and multi-layered coatings, creating eight lustrous sculptures formed in space.



Dan Coursen and Joseph McShane inspecting completed gold vapor deposition test at G.M. Vacuum Coating Laboratory.

Photographer: R. James Hills

The ninth and largest sphere is the simplest in concept, but the one that, for me at least, provides the greatest play of the human imagination. This 22,000ml sphere will ride into orbit containing a 15psi earth atmosphere. Once in orbit the Eptak 210 controller will direct a valve to open, linking the sphere directly to the vacuum of space. Over a three day period the sphere will attain an equilibrium with the vacuum of the orbit, becoming one with space. The valve will close and the sphere will return with the vacuum of space. A copper tube connecting the sphere to the valve will be cold welded, permanently sealing the sphere. Attached to the sphere is a 31GCH5-10 Baratron Capasitance Manometer, a vacuum gauge capable of a very exact digital reading of the vacuum in the sphere, expected to be in the $1x10^{-5}$ torr range.

The sculpture then is not the glass, but the outer space contained within. The sphere serves only to keep the one-g earth atmosphere from intruding on the space within, creating an anomaly of our common experience.

I would hope that this piece of sculpture, created using the tools of our technology, would find a place where one might view it as a "telescope of the imagination": observe, wonder about the nature and meaning of space, touch and know that only 1/8" of glass separates us from the purest outer space, a proximity to space heretofore reserved for only those few privileged to be astronauts.

"To see a World in a Grain of Sand
And Heaven in a Wild Flower
Hold Infinity in the palm of your hand
And Eternity in an hour."

William Blake
Auguries of Innocence

Joseph McShane inspecting an iridescent multi-layered coating on a 3,000 ml test sphere.

Photographer: Charles Lyon

The principle of vacuum thin film deposition (evaporation) is based on two concepts. First, some material is raised to a high enough temperature that it becomes a gas. Second, most of the gas must travel directly to the object being coated, the substrate, without first striking another molecule. This is, in effect, governed by "mean free path" conditions. If most molécules of evaporant reach the substrate unimpeded the coating will be reasonably dense and adherent.

The most common example of vacuum deposition is the dark coating in a light bulb that forms as the filament slowly evaporates itself. If that filament had been impregnated with aluminum, for example, the lamp would have become a shiny opaque ball the instant it was turned on.

By working at short distances in a clean vacuum of less than $1x10^{-5}$ torr, about 1/10,000,000 of an atmosphere, we expect to produce excellent coatings, in spite of some restrictions in the pumping speed caused by the restricted openings in the NASA lid and thermal cover. Extensive tests of the filaments and evaporation equipment have been run at G.M. Vacuum Coating Laboratory to verify the system's performance.

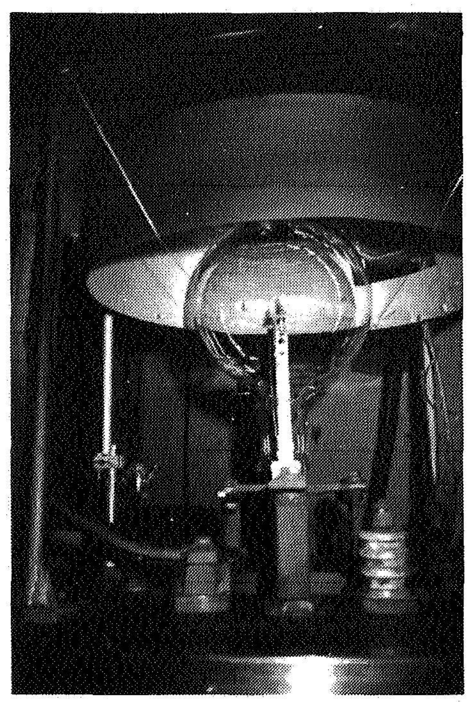
Sputtering is a unique type of vacuum deposition related to evaporation. In this case, molecules of the material to be deposited are mechanically knocked loose from a relatively cold source called the target. This is done by ionizing an inert gas at as low a pressure as practical and by charging the target negative, excellerating a positively charged gas, usually argon ions, into its surface. The reaction is similar to billiard ball behavior and target molecules are ejected by the impact of the ions at a high rate toward the substrate. In this type of system, the substrate is usually much closer to the source than in vapor deposition. This is why we elected to sputter the smaller spheres and evaporate in the larger ones.

It is our hope to use the space environment to our advantage. We can pump for several days without using power or adding contamination from organic oils often used in conventional vacuum pumps. We can also evapoate materials from filaments which normally tend to drip off during heat up and melt phase. In space the weightlessness should eliminate much of the risk of a droplet falling into the sphere.

The methods and results of G-38 will help supply useful data for simplified coatings of large antennas and heat shields in space where vacuum chamber size is unlimited. This device could have been made, for example, as a free floating module to coat rather large devices, such as bubbles, in space.

G-38 had three basic objectives. First, we were to design a sampling system to evacuate a large glass sphere with a vacuum gauge attached, seal it and return it in permanently sealed condition, allowing us to measure our working vacuum. Second, we were to perform eight depositions of thin films attempting to make best use of the space environment: vacuum, wightlessness and freedom from organic oil. The third task was to operate within budget limitations, using as much commercial technology as possible.

Several major areas of difficulty soon became apparent and we feel that in general they must apply to many GAS projects. Temperature swings in the experiment are a serious design challenge. If power were not limited, simple solutions would exist. We elected to use a cool option in designing the payload: insulate the experiment (with a few select thermal leaks where needed) and run a low density 6-watt heater to prevent battery freezing. It was in most cases easier to find materials to survive brief overheating in certain locations than it was to provide enough battery power to heat and cool the system. Some components, high current relays and evaporation filaments, generate up to 300-watts of heat for one or two minutes and then slowly leak it through polyimide foam to the rest of the system.



3 liter sphere with tungston filament in center, prepared for vacuum coating test.

Photographer: R. James Hills

The Eagle controller was selected for its E^2Prom memory, needing no backup power to retain program and current status inputs. Should battery power decline due to low temperature, the device merely waits for a warm cycle in the orbit and then continues. The same shutdown and continue mode occurs if over temperature sensors temporarily disconnect power and let the system cool down.

Location of space worthy materials was a major hurdle to overcome. Selection of excellent polymers to replace heavier metallic components was aided dramatically by the NASA Outgassing Data Compilation of Spacecraft Materials Publication 1014. An unusual example of plastic in place of more breakable ceramic is in the evapoation hardware. A piece of VR1040PPS is used to hold the filament and glow discharge cleaning electrodes. Only short manganese nickel leads isolate the hot tungston from the polymer support which has a working temperature above 500°F. Viton and TFE shrink tubing have eliminated many clamps and fittings in the system. The project would have been almost impossible without NASA's list of suppliers. Even so, obtaining specialized materials was a time consuming and frustrating challenge. Delivery times and prices can be shocking.

The power budget controls most final decisions in an experiment of this type. Our system needs both long term power for control and servo functions and high short term (1 minute/40amp) output for performing thermal evaporation and medium (2 hour/3amp) power for the sputtering tests. Since much of our experiment consists of light polyimide foam and empty glass spheres, battery weight was not the main problem. YUASA Captured Electrolite Calcium Lead Acid Batteries (sealed) were selected to meet the requirement and lab tests have been very encouraging. In spite of good batteries, we had to add a very low drain sleep cycle to our controller or it would have used too much power over seven days. At preset points in the program the controller turns itself completely off for six hours and then reactivates. During the off cycle current drain is about 12 micro amps. The E^2Prom memory retains currernt status of all valves and relays. The use of miniature filaments, from the R.D. Mathis Corporation, coated with the intended evaporant, allows short low power evaporation in three large spheres. A high fequency DC to DC converter drives the sputtering targets for a two hour coating cycle with metals tolerant to possible poor vacuum conditions, should all not go as well as expected. Globe gear motors and Swagelok plug valves running in a sealed nitrogen environment control the vacuum process and use power only when changing states.

Housing fabrication proved to be a challenging stumbling block. The most important lesson learned from this phase of the project is to select a single machine and welding shop that has helium leak test equipment and experience. Coordinating the difficulties of separate machining, welding and testing facilities is almost impossible. We found that stainless steel was so much more reliable to weld and fabricate that the weight and cost benefits of aluminum were negated. Of course, this may not be true for other experiments.

If all goes well, we will soon have a beautiful group of gold, platinum, chrome, aluminum and multi-layered spheres. But whether the experiment performs perfectly or not, it has been a challenging experience that none of us will forget.

As Jacob Bronowski said, "Man is unique not because he does science and he is unique not because he does art, but because science and art equally are expressions of his marvellous plasticity of mind."

The Greek root of Technology, Technical and Technique is TECHNĒ, meaning man's ART, CRAFT and SKILL.

From the cave as man first explored and strove to perfect his technē and continuing forth wherever he ventures, man leaves the imprint of his technē, saying: 'This is my mark. This is man.'

The hand of Anasazi man, painted 1200 years ago.

Photographed in the Grand Gulch of the San Juan Basin, Utah by Charles Lyon, Photographer for G-38, 39 and 40.

A VERSATILE STRUCTURE FOR GAS PAYLOADS

by

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ABSTRACT

This paper describes a structure, and some of its characteristics, which is to be used by the A&T Student Space Shuttle Program for carrying GAS experiments. The structure is sufficiently versatile that other GAS experimenters may be able to use it. The concept is easily capable of being extended to the 5 cu.ft. cannister.

DESCRIPTION OF STRUCTURE

The concept is simply that of a strong, square cross-section, central column to which experimental and accessory compartments are attached. The attachment may be by direct bolting or through vibration and/or thermal isolators, as needed.

It was felt that a hollow 4"x4", 1/2" wall thickness, 6061-T6 Aluminum column would be adequate. Because Aluminum tubes of these dimensions are not commercial stock items, it was fabricated in the following manner: Four 3/8" thick 6061-T6 Aluminum plates, two of which are 3.75" wide and the remaining two are 3" wide, were slid into a 4"x4",1/8" wall thickness, 6063-T5 Aluminum tube, and seam-welded at each end to the tube. (Chamfers were milled on the plates prior to welding to provide space for the weld material to enter and create a strong bond.) The ends of this composite column were milled to remove excess weld material, and to make its ends at right-angles to its sides. Details of the column are further elucidated in Figure 1. There is no reason for the choice of a different alloy for the outer tube other than that it was readily available.

The next step was to provide means for attaching the column to NASA's Standard Experiment Mounting Plate (NMP) [1], p.19, and [2], item (a), and to incorporate lateral supports [2], item (h). This was accomplished by constructing two initially identical 19.75" diameter, 1/4" thick, 6061-T6 Aluminum plates, with 3"x3", 0.75" deep, stubs at their centers each fabricated as follows: A 1" thick 6061-T6 Aluminum plate was milled down to 0.25" thickness leaving the stub at the center. (The reason for this method of manufacture is that bolting or welding a stub onto a 0.25" plate could, it was felt, create strength problems.) The remaining 0.25" plate was held through four holes on a rotary table and the edge was milled to 19.75" diameter. Eight countersunk clearance holes, two per side, were drilled at each end of the column, corresponding holes were drilled and tapped in the stubs to accept Tridair KN420J inserts [3] , and the column was secured , using Unbrako 1960 series 1/4-20x3/4", alloy steel socket head cap screws [4] , to the stubs. One plate is intended for attachment to NMP, the other to carry lateral supports. We shall refer to these, respectively, as A&T's Top Plate (ATP) and A&T's Bottom Plate (ABP). This assembly is shown in Figure 2.

It was initially felt that the attachment of ATP to NMP should incorporate thermal isolators. For this purpose twelve Polypenco Nylon 101(6/6) [5] spacers, each as specified in Figure 3, were fabricated and inserted at twelve locations in ATP. Twelve Unbrako 1960 series 10-32x1.25" alloy steel socket head cap screws [4] are expected to be adequate to hold the complete structure and apparatus (total weight at most 100 lbs.) to NMP during flight. Details of the mounting of ATP to NMP are shown in Figure 3. This method of mounting creates an air space, and puts Nylon barriers in the heat conduction path between ATP and NMP. The efficacy of this device, as a thermal isolator, will be commented upon in the next section. However, the air gap remains necessary to prevent obstruction of the purge ports and grounding points on NMP. The four holes in ATP which were used to hold it down for machining purposes now serve to provide convenient access to NMP for a grounding strap, plumbing for possible venting of batteries, and permit purging.

The structure uses four lateral supports, each mounted on top of ABP with four Unbrako 1960 series 10-32x7/8" alloy steel socket head cap screws [4] . The locations of the lateral supports are shown in Figure 4. The details of a lateral support are shown in Figure 5. It consists of a threaded base through which a 1/2-13 galvanized steel threaded rod moves. The rod is provided with a lock nut. One end of the rod is squared to allow the use of a wrench to turn it; the other end is turned and press-fitted into the cone (part no. A2037) of a Timken tapered roller bearing. The cup (part no. A2126) of the bearing is mounted in a Polypenco Nylon 101(6/6) [5] bumper made according to [2], item (h). The operation is simply that of turning the threaded rods by a wrench through slots in ABP until the bumpers press against the GAS cannister walls as much as desired. The lock nuts are tightened to prevent the threaded rod from vibrating loose during launch.

The structure described above can easily be used in the 5 cu. ft. cannister by constructing a longer central column, possibly increasing the thickness of the Top and Bottom Plates (in which case the stubs may be bolted), and possibly increasing the number of screws holding the Top Plate to NMP.

CHARACTERISTICS OF STRUCTURE

This section contains a brief presentation of some characteristics of the structure which are publishable at this time. The characteristics mentioned below are among those which are required to be considered by NASA-NHB 16700.7A [6] , the associated Gas Payload Safety Manual [7] , the GAS Experimenter Handbook [1] , and A&T's own requirements.

A) Structural:

The following format coincides with that in the Structures Hazards Checklist of the Safety Manual [7] , pp.165-169.

Structural Analyses

a. The presentation of a detailed stress analysis according to the requirements of Appendix A of [7] is beyond the scope of this paper. It suffices to say that our preliminary estimates have shown that all elements in the structure are capable of withstanding the flight loads with more than the margin of safety required.

It is of importance to obtain some insight into the vibration frequencies of the structure without any chambers attached to the column. The structure will be excited by the motion of NMP. If we regard the ATP and NMP assembly as a rigid body the column may be regarded as an elastic body which is clamped at its upper end and attached to an elastic support (i.e., ABP) at its lower end. Utilizing the general principle that stiffening a structure raises its vibration frequencies, we may obtain lower bounds to the frequencies of the column by regarding it as free at its lower end. In this manner, we find that all longitudinal vibration frequencies are greater than

1225 Hz

and all lateral vibration frequencies are greater than

333 Hz

These values are far in excess of the minimum value 35 Hz specified by Appendix A of [7]. We therefore conclude that the column is rigid with respect to any vibratory excitations transmitted by NMP. These excitations will be transmitted almost unaltered to ABP. It now becomes important to consider vibration frequencies of ABP. Because ABP is supported in a complicated manner, we must resort to the following technique for their determination: ABP is certainly far more stiff than a 19.75" diameter, 0.25" thick Aluminum plate which is clamped at its boundary, because of the 4"x4" region in ABP which is also clamped. The fundamental frequency of the former plate is

74 Hz

We conclude therefore that neither the column nor ABP will resonate.

b. With the exception of items (4) & (9), which are procedural requirements which will be followed in structural analyses, it will be easily seen that all other general practices listed have been followed.

Structural Materials

At the time of writing we have not convincingly demonstrated to ourselves that damaging stress corrosion cracking, hydrogen embrittlement, or galvanic corrosion will not occur. Nor have we checked that the materials have sufficient fracture toughness to be able to tolerate cracks of those sizes which may be expected. Studies of this sort will take place soon after we obtain documentation of reliable recommended practice such as NASA-MSFC-SPEC-522A.

Structural Supports

It will be seen that all requirements of this section have been met. These will also be taken into consideration in the design of supports for the chambers which are to be attached to the column.

B) Thermal:

It is of considerable interest to know how well the structure is thermally isolated from the cannister. For this purpose, we have done some calculations assuming that the structure and cannister inner wall are at constant temperature, and heat flows between them in the following modes:

i) Conduction through Nylon-Cap Screw Assembly
ii) Conduction through Air Gap between ATP and NMP
iii) Conduction through Lateral Supports
iv) Radiation from ATP and ABP to Cannister Inner Wall

If Q denotes the heat flow rate, TC denotes cannister inner wall temperature, and TS denotes structure temperature, the energy balance equation reads as below:

$$G_r\,(TS)^4 + G_c\,(TS) = Q + G_r\,(TC)^4 + G_c\,(TC)$$

where the G's are calculable heat conductances.

Given the space available for battery storage, we expect to be able to provide a maximum value for Q of 2.4 watts. Assuming TC = -15 degrees Centigrade, the above equation can be solved for TS to give

TS = -14.8 degrees Centigrade

The above calculation is an important one showing that with 2.4 watts of power available for heating, there is practically no thermal isolation of the structure from the cannister. They are practically at the same temperature. We do not expect to be able to raise the power available for heating too much beyond 2.4 watts because of battery space unavailability. We may therefore question the necesssity for the Nylon spacers and use metal spacers instead. It is also apparent that any desired temperature control of experimental and accessory chambers must take place by insulation and heating of the chambers directly.

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3. Keenserts, Catalog No. 200-E, Tridair Industries.
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6. NASA-NHB 1700.7A, Safety Policy and Requirements for Payloads Using the Space Transportation System.
7. GAS Payloads Safety Manual, NASA-GSFC, Nov. 1983.

Acknowledgement: The author wishes to express his deeply felt gratitude to all the members of the A&T Student Space Shuttle Program for their contribution and enthusiasm. In particular, the names Edwin Crabtree and Nathaniel Hines II must be mentioned in connection with the specific work outlined in this paper.

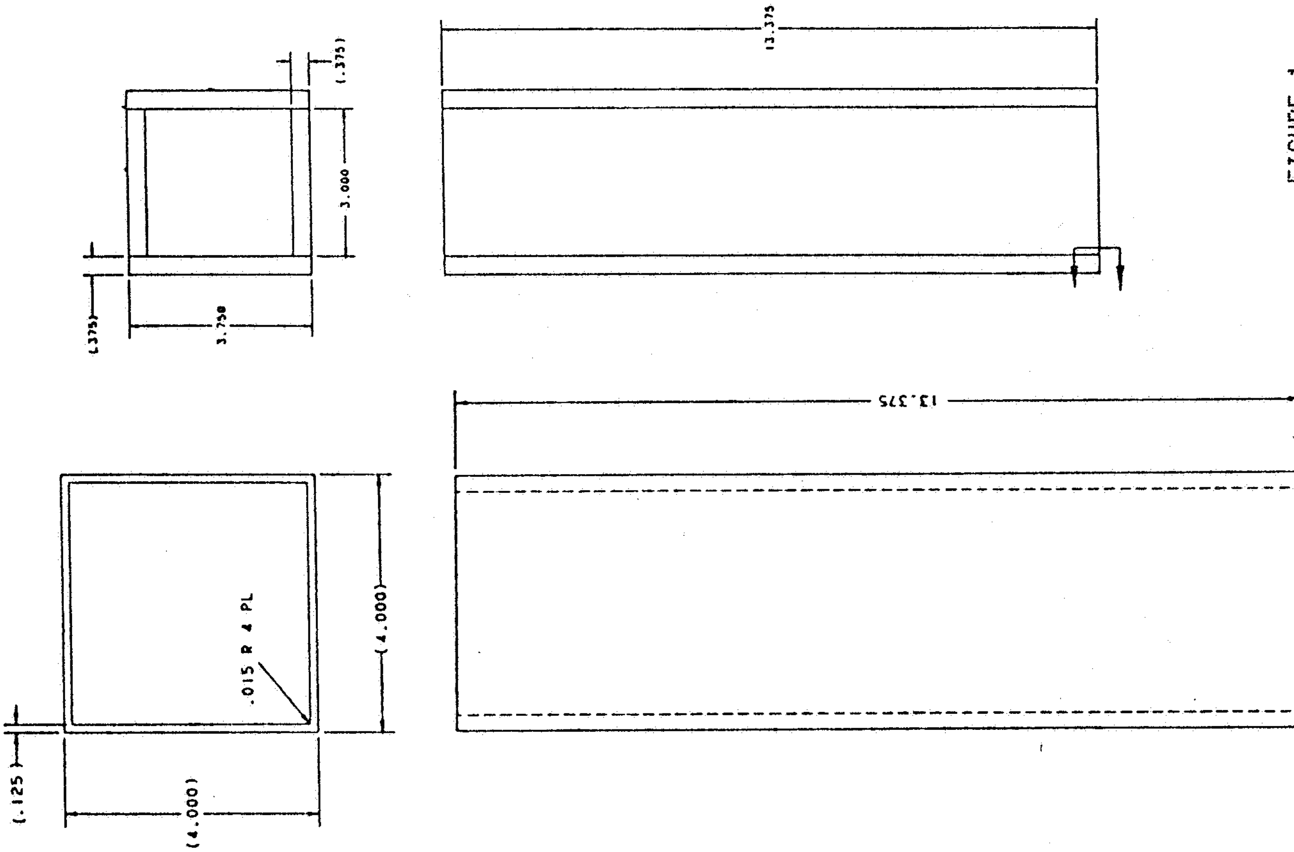


FIGURE 1

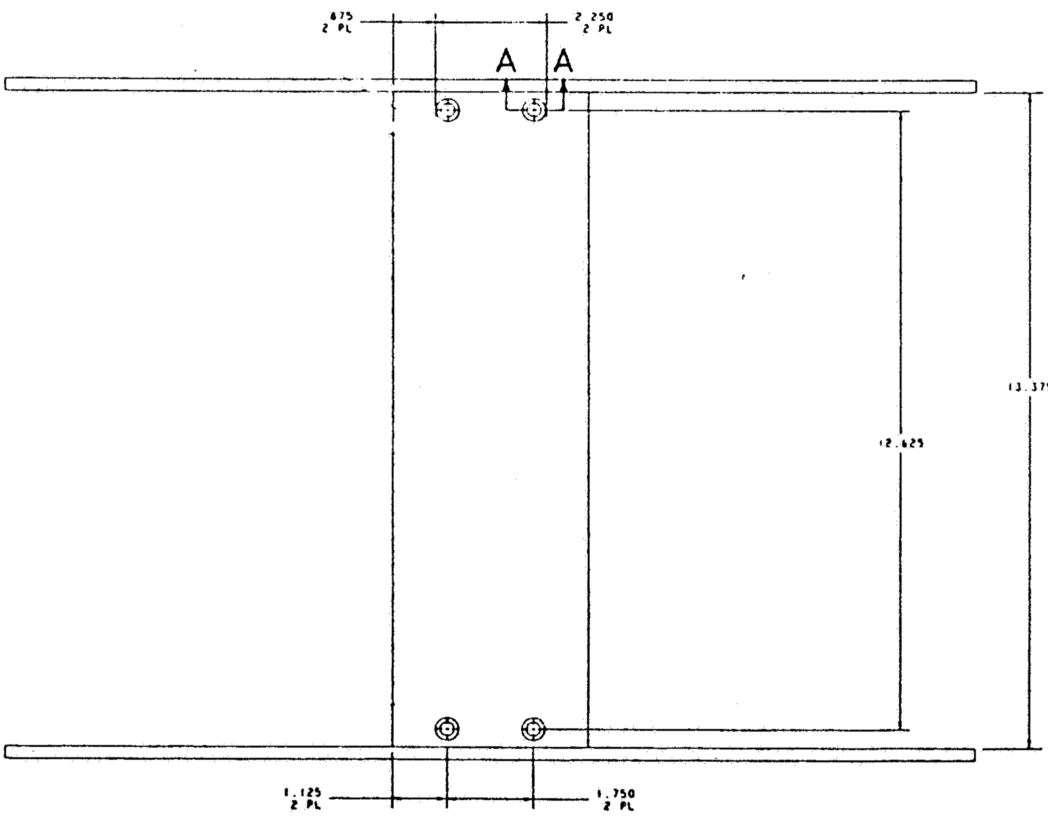
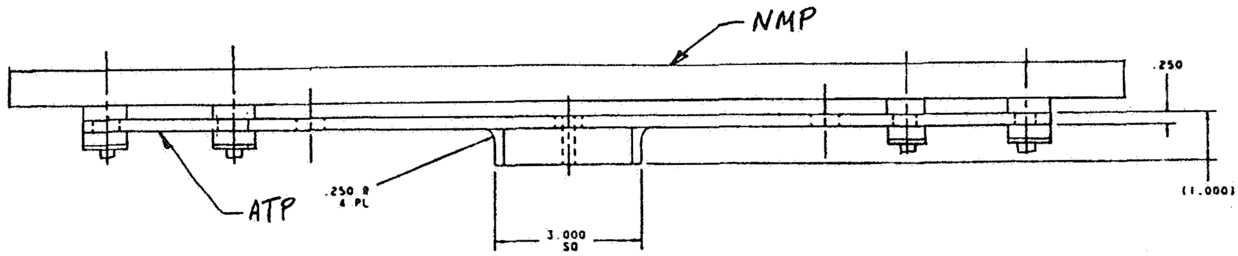


FIGURE 2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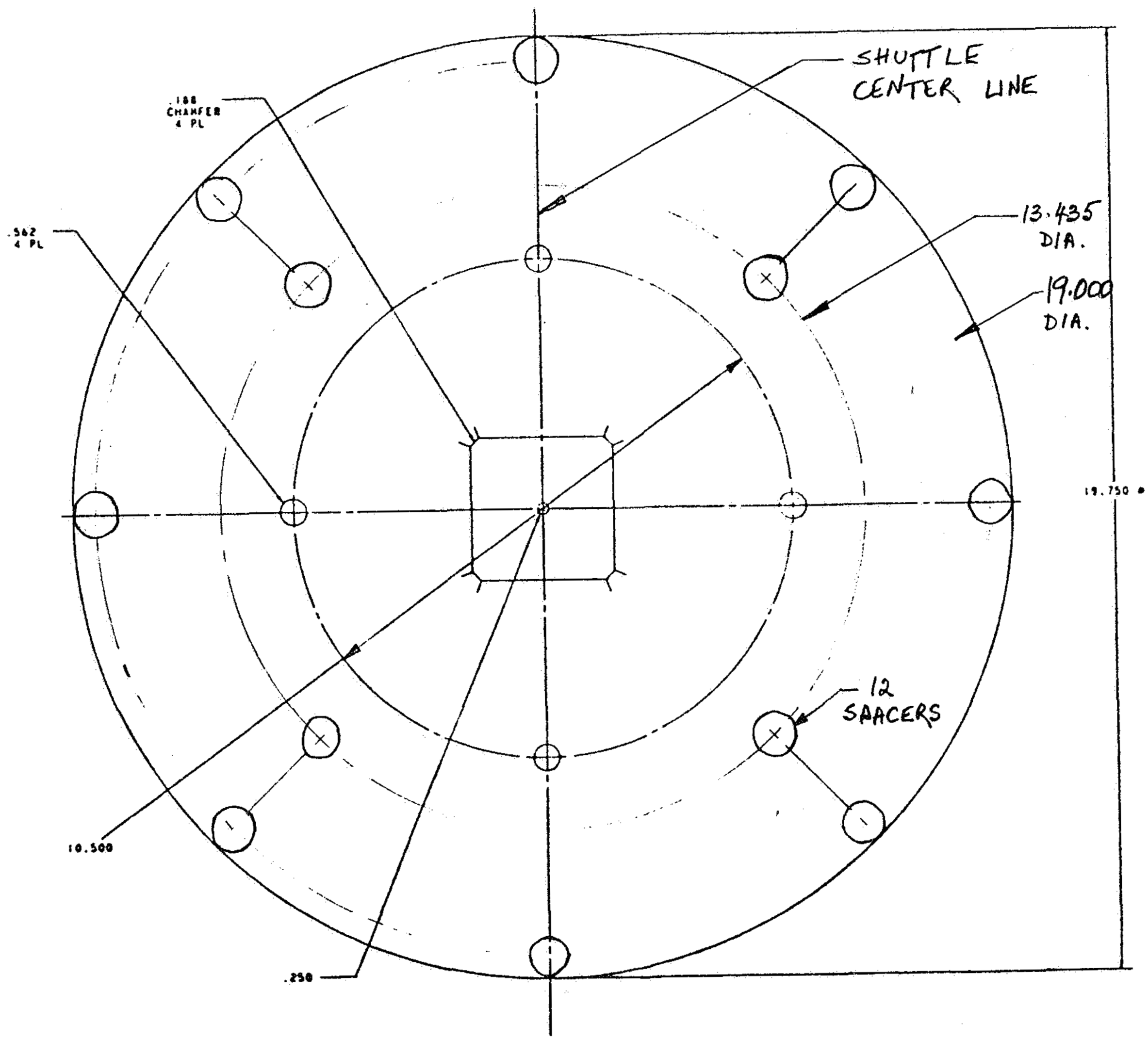
.250
ATP
.250 R
4 PL
(1.000)
3.000
SQ


SHUTTLE
CENTER LINE
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CHAMFER
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DIA.
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DIA.
19.750
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SPACERS
10.500
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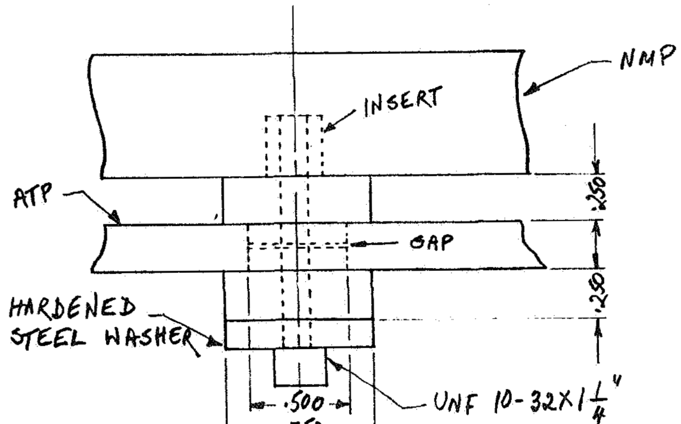
NMP
INSERT
ATP
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GAP
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HARDENED
STEEL WASHER
.500
UNF 10-32X1 1/4"
.750

FIGURE 3

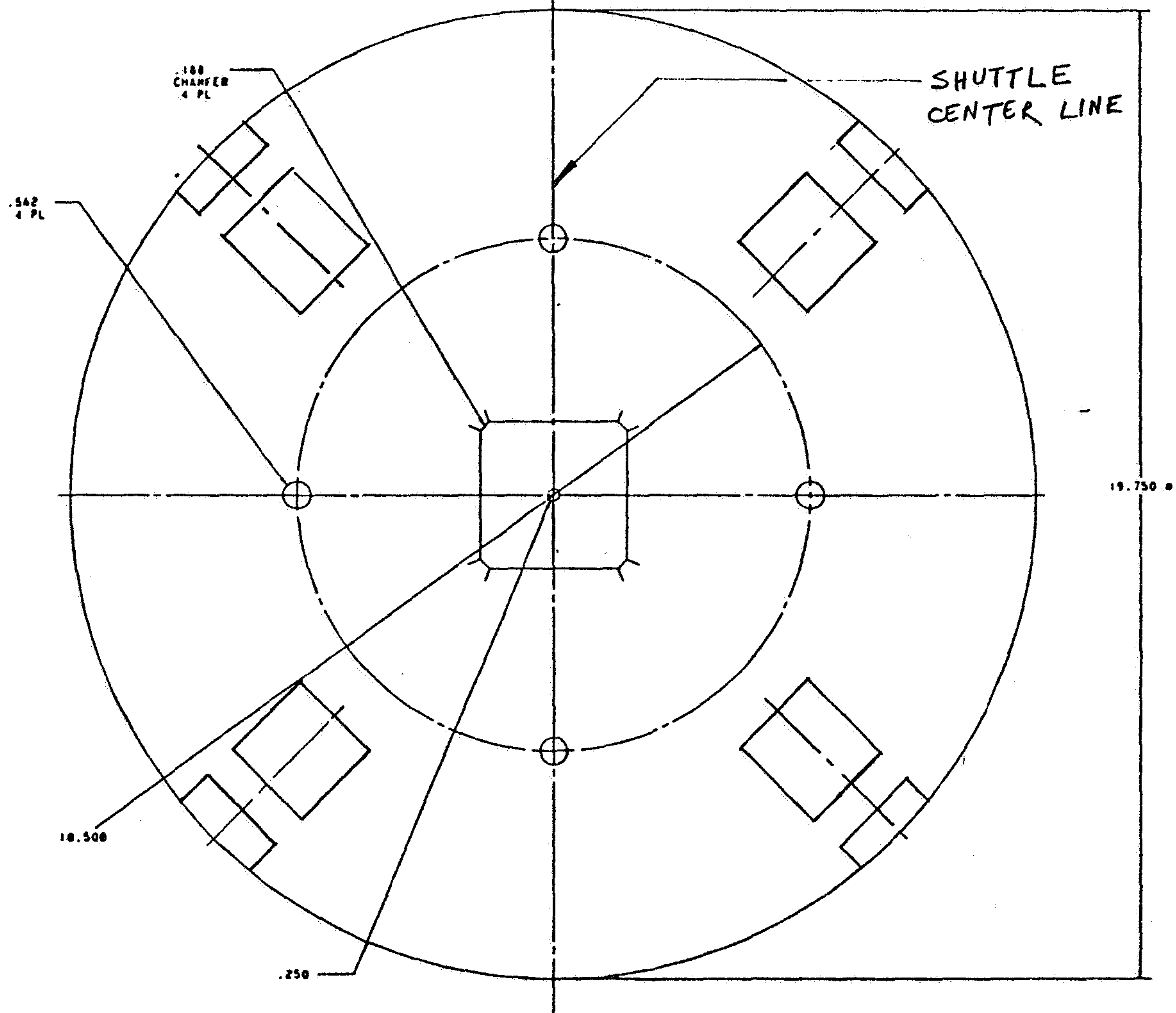
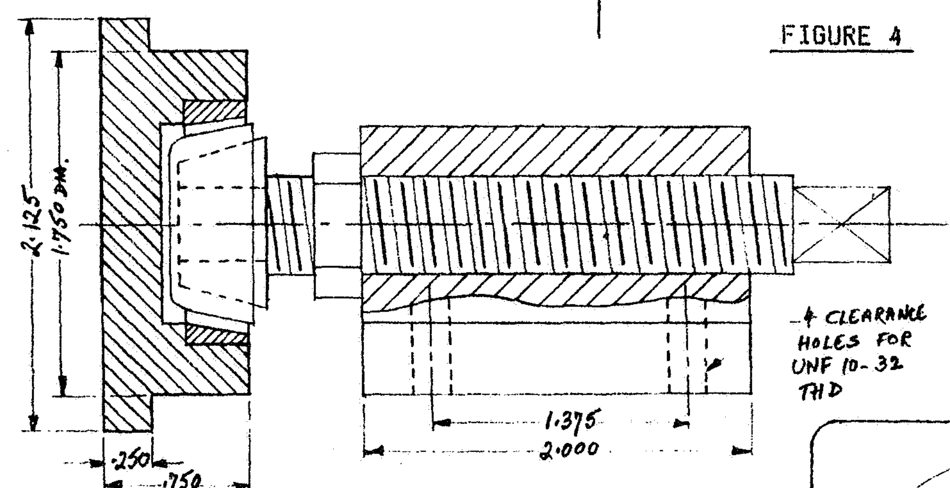


FIGURE 4



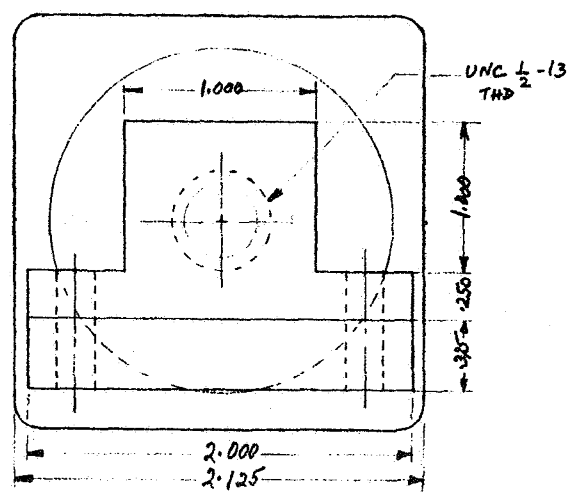


FIGURE 5

THE G-002 JUFO-1 PAYLOAD, ITS OBJECTIVES AND RESULTS

Guenter Schmitt
Kayser-Threde GmbH
Munich, FRG

Objectives:

The G-002 JUFO-1 payload was successfully flown during the STS-7 mission in June 1983.

It was intended to:

- establish a forum for space relevant experiments of high school and university students

- demonstrate that simple and cheap technology can be flown on the shuttle without compromising safety and reliability

- experience the capabilities of the GAS flight opportunities, its advantages and restraints

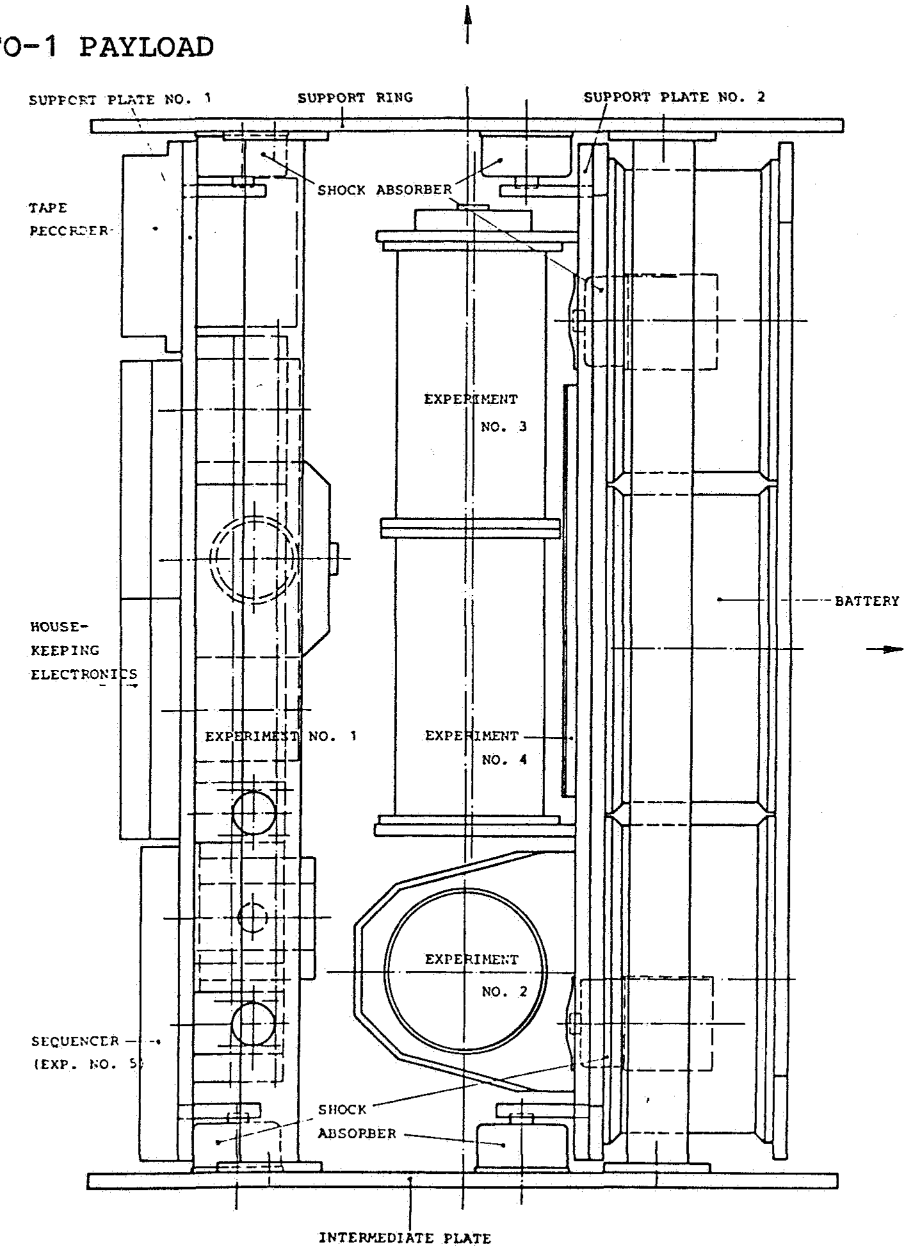
- evaluate proceeding of different experiment types mainly with respect to the long standby time ahead of the mission

Concept of payload and its operation:

The payload basically consists of the mechanical support structure with two shock isolated mounting shelves for the experiment hardware and the service systems.

For the envisaged operation time of 72 hours three 28 VDC batteries, with a total capacity of approx 1,7 kWh are chosen as partially redundant power source.

G-002 JUFO-1 PAYLOAD



Every minute, experiment and housekeeping data are acquired by a 12 bit PCM system and stored on a cassette tape recorder. The PCM system provides twelve analog and four digital channels at a data rate of 5 kbit/sec.

Payload and experiments are activated by switching the GAS relay contacts and are controlled by an internal sequencer.

In order to maintain adequate payload temperatures at a low power consumption, a thermally insulated endplate was used with the GAS container.

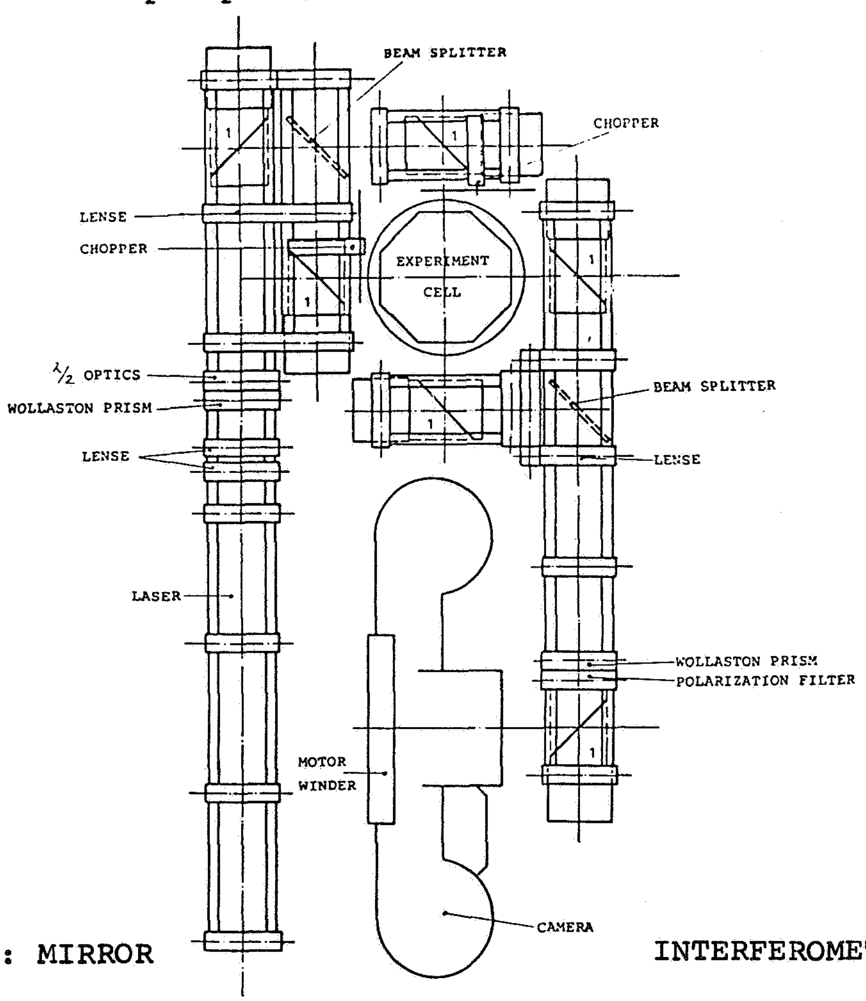
Experiments in various areas of science:

Five experiments, concerning physics, chemistry, biology and technology were carried within this payload.

Experiment no. 1): Crystal growth

The growth of a crystal in a liquid $KH_2 PO_4$ salt solution - saturated at 60 ^oC - was observed under micro gravity environment.

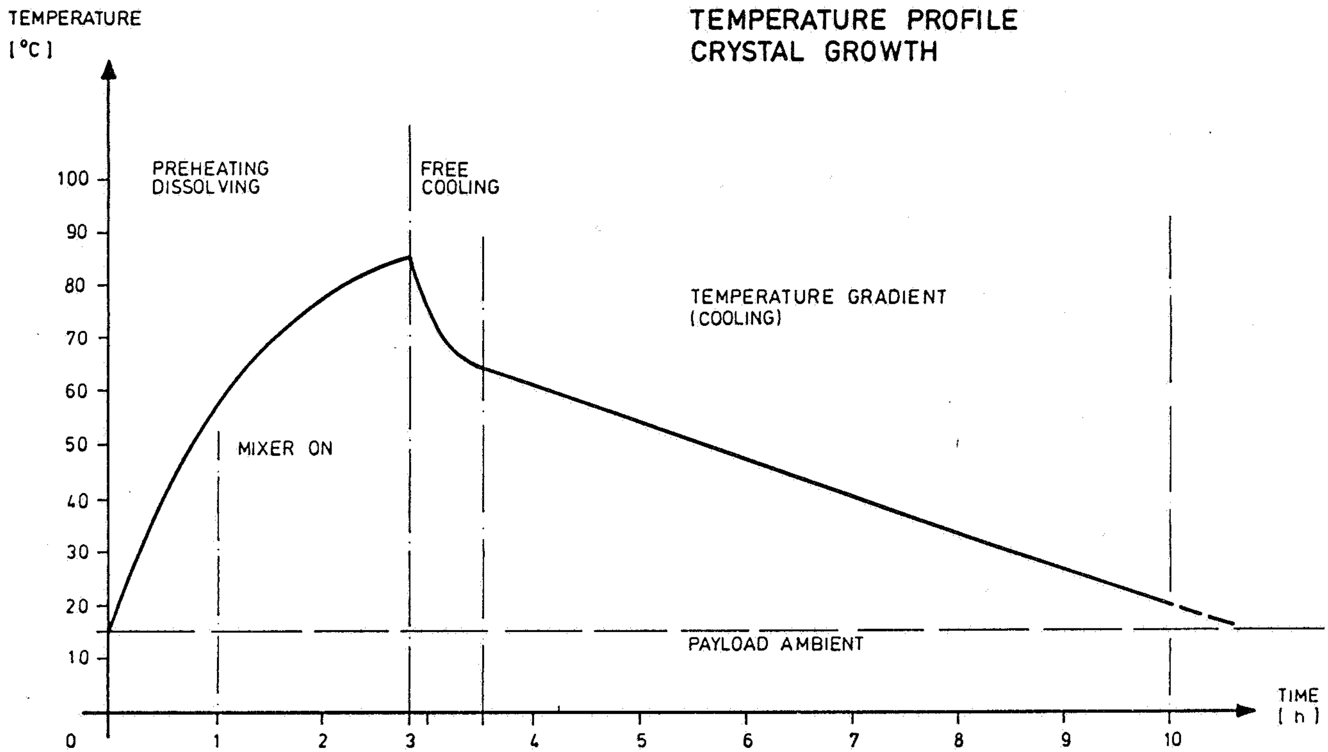
A thermally isolated experiment cell, furnished with four orthogonal, optical windows, four foil heaters (20 W), a mixer and a neoprene membrane contains approx 160 ccm liquid solution. Leading across the cell a nylon rope acts as an initiator for crystal growth in the center of the cell. The experiment cell is integrated into a laser Doppler interferometer with an orthogonally splitted H_e-N_e laser beam of approx. 0,5 mW output power.



1 : MIRROR

INTERFEROMETER

During the controlled cooling period of the experiment density structures of the solution around the growing crystal are detected.



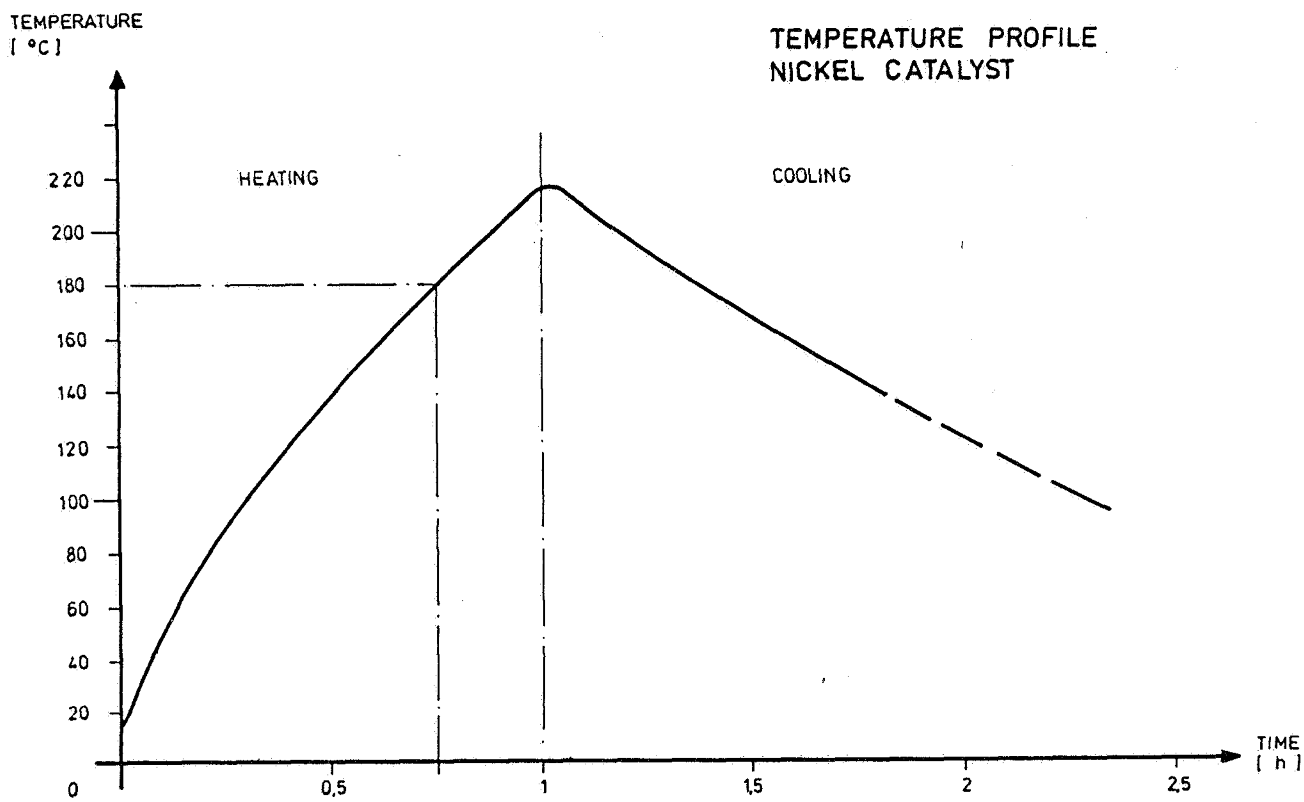
Every four minutes two pictures of interferograms in orthogonal planes are taken in between ten seconds. Though a total of 250 interferograms is registered by a photographic camera. For association to the recorded temperature data the experiment time is displayed on each picture.

The experiment performed as expected, the predetermined temperature profile was achieved, a crystal was growing in the center of the cell and stills of interferograms were obtained. One optical window could not be cleared completely because some salt crystals didn't get dissolved during the preheating phase. Some unexpected gas bubbles caused disturbancies in the density structures, too. Some of the experiment results are still evaluated at the present time.

Experiment no. 2): Nickel catalysts

Nickel catalysts were manufactured by thermal processing of four specimen cartridges inside a furnace.

The 55 W isothermal furnace heats up four nickel cartridges to 240 ^{o}C. Each cartridge contains a mixture of potassium hydroxide/nickel formiate or sodium hydroxide/nickel formiate and dry nitrogen to avoid moisture.



During the heating period the materials inside the cartridges are exposed to a temperature environment above 180 ^{o}C for more than 15 minutes and a peak temperature minimum of 205 ^{o}C. After reaching a predetermined temperature the furnace gets switched off while the cartridges are cooled down passively. The furnace performed as predicted.

A comparison of ground test results with "in space" and "on earth" processed nickel catalysts shows significant differences. In space processed catalysts experience higher efficiency. The experiment results are still under evaluation.

Experiment no. 3): Plant contamination

Water cress shoots were used to determine the transport mechanisms of heavy metals in plants.

Three cylindrical growth compartments contain approx. 60 seeds each, liquids for initiation and fixation stored in standard syringes and air at atmospheric pressure.
The seeds are glued to cellulose wadding at the bottom of bores in plexiglass cylinders. For initiation of the experiment spring loaded plungers are released and the liquids are injected into the wadding using $H_2O/Cd\ (NO_3)_2$ solution with two compartments and H_2O with the third. The temperature is controlled closely to 24 ^oC during the three day experiment activation time. Within this period three 12 hours day/night cycles are simulated by LED arrays. For fixation of the seeds after three days saturated Reinecke salt solution is injected into two compartments while formaldehyd and methanol stabilized in H_2O is injected into the third.

The experiment performed satisfactorily. Some plungers could not be driven by its spring load after release most likely because of the long standby period.

However micro cuts through the "in space" developped plants show significant differences in their cell structures compared with plants grown on earth. Traces of Cd have been detected in the plant shoots. Some of the results are still to be evaluated.

Experiment no. 4): Biostack

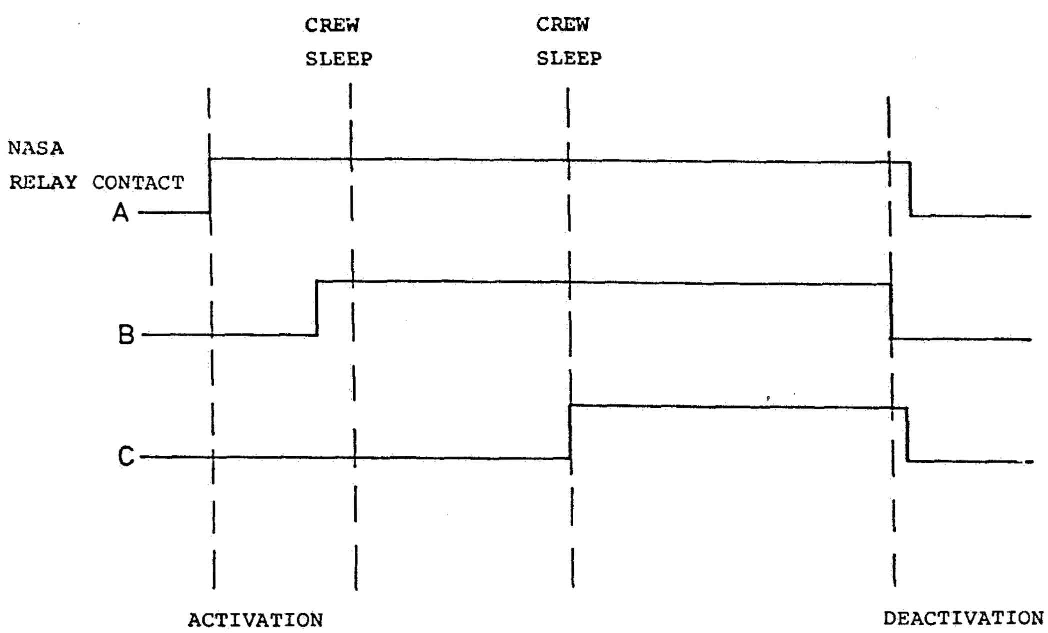
The biostack was designed to determine the influence of cosmic radiation on plant seeds.

Four different plant seeds - wheat, grain, oats and beans - are embedded in single bores of flat plexiglass blocks. Diallyl-diglycolcarbonate foil is attached to top and bottom of each block to detect and locate impact of particles.

Mostly impacts of α-particles were detected, however, three impacts of heavy particles were located. Comparing plant development tests are still in progress and not finished yet.

Experiment no. 5): Microprocessor-sequencer

The microprocessor controlled sequencer uses a new approach for payload control and sequencing at a low power consumption.



G-002 TIMLINING

All payload functions are timed by the sequencer based on a NSC 800 CPU. Its main routine is activated by GAS relay contact A. This routine controls data acquisition, tape recorder, housekeeping system and water cress experiment during the whole payload operation time. Subroutines for timing of crystal growth and nickel catalysts experiments are initiated by GAS relay contacts B and C. Therefore redundancy is obtained in processing the different experiments. The sequencer performed as predicted.

Summary:

The G-002 JUFO-1 payload was very successful under the aspect of its objectives. Micro gravity relevant scientific results were obtained.

However, critical items were experienced due to the long stand-by period of two months and more in advance of the mission. Nevertheless, a basis to maintain a low cost program with frequent flights could be established encouraging junior scientists to participate in space activities. Today a follow on mission is already planned.

GAS - 286

ULTRALIGHT REACTIVE METAL FOAMS PRODUCED AS STRUCTURAL SHAPES IN SPACE: SYSTEM DESIGN

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Introduction. A series of studies both inside and outside of NASA have concluded that the production of foamed metals is an important space-manufacturing possibility (1-6). It is possible to produce foamed metals on earth by a variety of powder metallurgical and other methods (7-10); therefore it is unlikely that it would be economical to produce structural foamed metals in space and then return them to earth for actual use. Produced in space for use in space, however, foamed metals can have very significant structural advantages (11). In the absence of substantially all air and water vapor (although traces of active gases are present in near earth orbits) it is possible to use ultralight reactive metals such as Mg-Li alloys of high lithium content, whose use on earth in structural applications is precluded. The use of such alloys would enable extremely light (0.1 g/cc) foams to be produced. By foaming such materials in orbit into useful shapes such as I-beams, earth based handling is made very much easier. Substantial studies are currently underway to investigate the mechanical fabrication of trusses and triangular beams in orbit from solid, non-foamed materials but there appears to have been little or no effort directed to the in situ production of structural members by foaming methods. Certainly there has been no work done involving the use of ultra-light alloys. As large scale space engineering projects are considered, the stiffness, strength, and density of the materials chosen becomes of increasing importance and ultra-light reactive foams produced as structural shapes in space may well offer significant engineering advantages, particularly for satellite armour applications. In the following sections we describe our GAS payload design, which is designed to produce I-beam shapes of Al-Mg-Zn, Mg-Al, and Mg-Al-Li-Ca alloys.

Systems and Subsystems: Experiment Design

The Duke-Omni GAS 286 payload dimensions are 2.5 cubic feet and 60 pounds. Engineering is constrained by NASA safety guidelines and regulations as outlined in NHB 1700-7A (Safety Policy and Requirements for Payloads Using the Space Transportation System) and the GAS Safety Manual. Implementation of the experiment was also heavily constrained by the expected storage lifetime before launch of the sealed experiment (approximately 90 days). This long storage time precludes the use of Ni-Cd batteries whose self discharge rates approach 1-3 % per day.

This autonomous experiment for foaming metals in space involved (a) payload support structure; (b) furnace and foaming apparatus; (c) electronic controls; (d) battery power; and (e) metallurgy. Emphasis was laid on a modular design which was easily modifiable and which offered maximum durability, safety, and failure tolerance.

Payload Support Structure. This design primarily requires a skeleton with a high strength-to-weight ratio capable of withstanding a 10 g acceleration along the axis of the payload and a 6 g acceleration transverse to this axis, as might be experienced in an emergency landing. The ultimate factor of safety should be at least 1.5 if verified by test or 2.0 if verified by analysis. Our payload has a f.s. of greater than 2.0 verified by mechanical tests.

Figure 1 shows an overview of the basic payload support structure. The payload pallet plate is held to the NASA top-plate by sixteen steel bolts extending through individual thermal stand-off washers. Lateral support at the top-plate end is accomplished with eight bumper assemblies.

The design of the bumpers is shown in Figure 2. This design consists of a 6061-T6 aluminum bracket, one side of which is bolted to the Duke "bottom-plate." The bolt which drives the bumper plate has a rotatable foot of the type used in C-clamps, attached using silver-solder to the steel bumper plate. This plate is four square inches in area and has a ten inch radius of curvature to conform to the walls of the cylinder. The surface of the plate is covered with a sheet of Viton, an extended temperature range synthetic rubber.

The primary load-carrying structure consists of two 1/4" end or pallet plates held 8 inches apart by

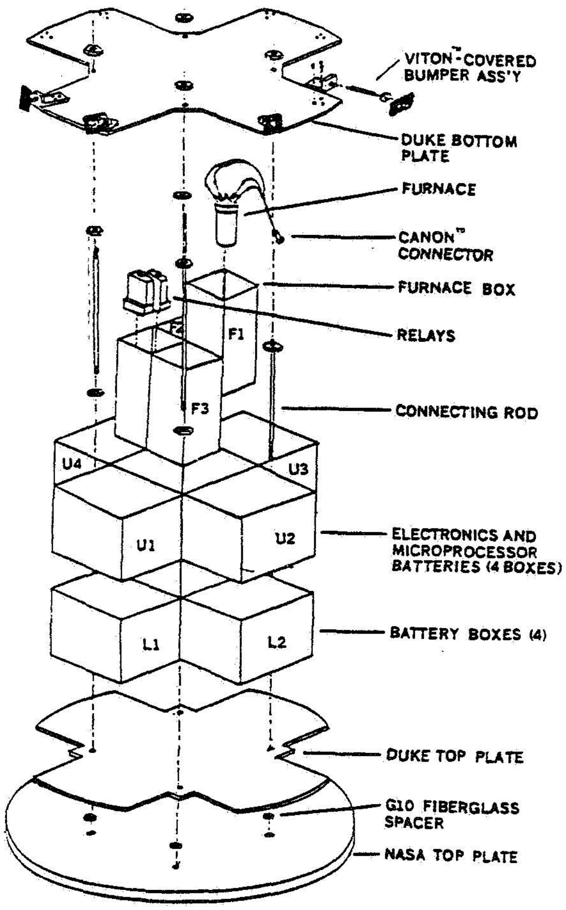


Figure 1. Support structure, exploded view.
U = Microprocessor System.
L = Furnace Power Batteries.
F = Furnace Housings.

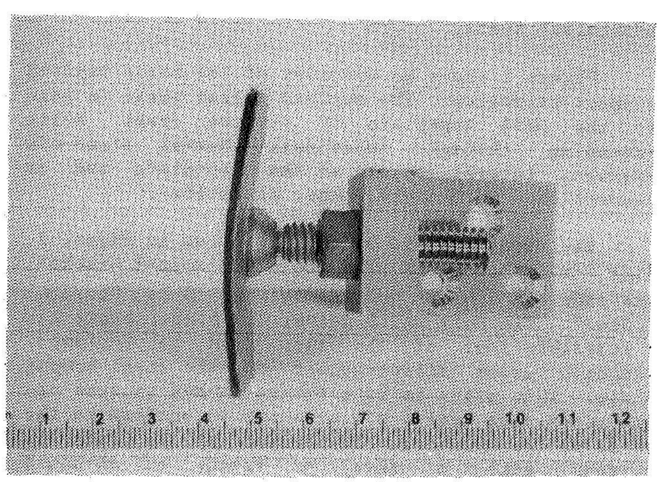


Figure 2. Bumper, top view. Scale in cm.

four 3/8" rods and eight 1/2"x1/2" corner brackets, all machined out of 6061-T4 aluminum. This alloy in this temper is very resistant to stress corrosion cracking. Twelve type 1100 aluminum sheet metal boxes are fastened between the plates, each box containing a separate subsystem. This use of multiple boxes allows for a modular and flexible design. All electrical interconnections between boxes were realized using Canon mil. spec. connectors.

As stated, the Duke top-plate is fastened to the NASA-provided top-plate by sixteen steel bolts. The use of our own top-plate allows us to transfer the entire assembly to the final launch container intact and as a single unit. In order to minimize the response of the payload to temperature changes on the outside of the canister, the Duke top-plate is separated from the NASA-provided top-plate using 3/8" thick thermal stand-offs 1/2" in diameter made of G-10 (a phenolic material impregnated with glass fibers). The final structure is covered with a foil designed to minimize the emissivity of the payload, thereby minimizing the radiation heat transfer from the payload to the cannister. The foil chosen is type #852 aluminum on Mylar (with acrylic adhesive) purchased from the 3M Company. The use of thermal stand-offs and reflective coatings is critically important if excessively low payload temperatures are to be avoided.

Alloy steel fasteners were used in all cases due to their high strength. Lockwashers were used liberally to prevent vibration from loosening connections.

Battery Power. Temperature considerations play a key role in determining the design of the experiment. The primary problem is the fact that a fully charged battery contains progressively less usable energy as the temperature of the cell drops. Thus in the worst case, where the shuttle tail is pointing to the sun, the bay area is radiating into deep space. The equilibrium temperature for the batteries in this flight attitude would be -100 C (see GAS Thermal Design Summary, X-732-83-8). This is unacceptable for any choice of batteries. A well insulated payload requires a relatively long time (several days) to approach such temperatures.

Many different types of batteries were considered for use, including Ni-Cd cells and primary (non-rechargeable) cells. Gates sealed rechargeable lead-acid D-cell (2 volt) sized batteries (Gates Energy Products, Denver, Colorado) were chosen for their ability to supply high (2 amp) current rates at low (-40 C) temperatures, their lack of free electrolyte, and their sealed nature. Even though sealed, they will still release significant hydrogen especially after charging but will not release oxygen. Such D cells have a capacity of 18,000 joules per cell fully charged (room temperature), as well as acceptable operation when cooled down to -40 C. The D-Cells were relatively easy to mount into boxes, and are provided with plus-and-minus tabs on the same side of the cell; the latter feature proved to be a great advantage mechanically over the typical flashlight battery design, because lug terminals could be used to make all electrical connections.

Each furnace requires roughly 50,000 joules of energy, including heat lost to the environment, to reach approximately 650 C. Because the payload may sit on the orbiter up to 90 days, the cells are assumed to be only 3/4 charged by the time of lift off. In addition, because the experiment may be run at very low temperature, the remaining available energy within each cell is assumed further cut in half, leaving a state of about 35 % charge or roughly 5000 joules per battery. With this rationale we have allotted 18 batteries for each of three experiments for a total of 54 cells. The furnace requires twelve volts, allowing each set of 18 to be composed of three stacks of six connected in parallel. Each stack of six is diode protected (two 2.5 amp diodes in parallel) to prevent a stronger stack from recharging a lower voltage stack, thus preventing the consequent release of hydrogen gas. Each set of 18 uses a 10 amp fuse in line in case of an electrical short. As a result, roughly 90,000 joules is provided for each 50,000 joule experiment. With this excess capacity, the experiment should still function even with the failure of one stack of six batteries, as might occur with the failure of a single cell.

The battery housing is shown in Figure 3. Twelve batteries per box are allotted to 4"x5"x6" boxes. Thus four and one-half boxes are required for the lead acid batteries. Batteries are held by right-handed and left-handed "S-curves" (upper and lower, respectively), plus a template in the middle. The batteries rest on a fiberglass mat on the box bottom, and are held on top by an aluminum retainer bar.

All aluminum parts within the battery boxes are coated with PT-201 Epoxy Resin coating. This paint is designed to resist highly corrosive environments. PT-201 is NASA-approved, provided a bake out at 360 F for 1 hour is used to remove volatiles (Products/Techniques, Inc., Los Angeles, California). Between the batteries and the box bottom we have placed 2-ply fiberglass cloth for additional thermal insulation (Aircraft Spruce & Specialty Co., Fullerton, CA). The interstices of the batteries are filled with fiberglass-covered acid-absorbing pillows which contain sodium silicate

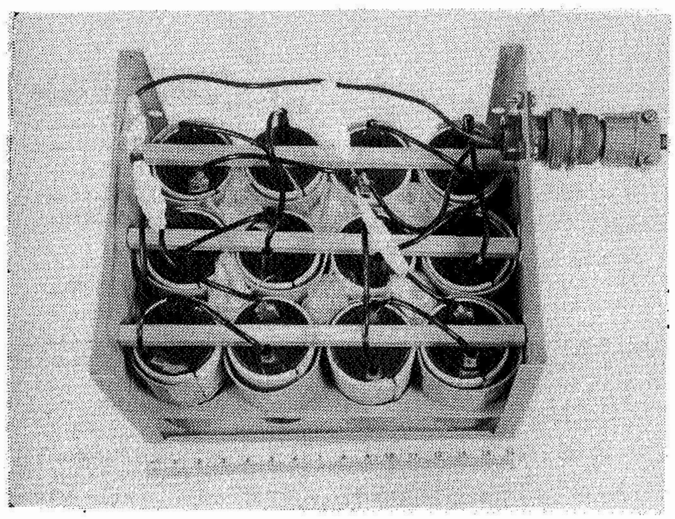


Figure 3. Housing for 12 lead-acid batteries, top view. Diodes in white, placed in line with battery stacks of six. Scale in cm.

to absorb any possible spillage even though those batteries normally do not contain free electrolyte.

Electronics and Controls. This payload utilizes industrial and military (rather than commercial) components wherever possible, together with back-up systems where appropriate. The overall electrical schematic is shown in Figure 4.

Two completely independent systems were employed in order to decrease the severity of a single component failure. A dedicated microprocessor, described below, was used for measurement of temperature change and control of two of the furnaces, utilizing 36 batteries. Such temperature measurements allow for flexible controls in order to get the most out of batteries performing at low temperatures; but this advantage must be weighed against an increased chance for control failure. Therefore a second, relay-controlled system was employed to run the third furnace. This second system is composed of two mechanical relays (R13 and R14) and controls 18 batteries. The basic relay system is considered highly reliable but takes no account of temperature. As a result, furnace 3 runs immediately upon payload activation.

In order to prevent the batteries from being drained to exhaustion in the event of a microprocessor or other failure, all power to the furnaces flows through voltage sensitive relays (R4 and R13) which open the circuit if battery voltage drops below 9.5 volts (5 % of battery power remaining). Additionally, timed relays (R11, R12, and R14) are used in line with each furnace so that total heating time can be controlled to fixed lengths (typically 10 minutes). (Relays R11 and R12 are redundant when the microprocessor is functioning correctly.)

The microprocessor controls the heating sequence for furnaces F1 and F2. Its internal design is described under a separate heading. Furnace F1 is activated by causing output line H1 to go high. This activates the power bus (relay R4) through relay R2; output H1 also causes relays R6 and R9 to close, therefore sending power to the furnace coils. The microprocessor sends output H1 low again after either 10 or 15 minutes, thereby shutting off the furnace. After allowing the lead acid batteries to recover (1/2 hour), furnace F2 is activated in a similar fashion. Power is not put to the coils on voltage sensing relay R4 until power is to be run to furnace F1 or F2, in order to conserve energy.

In order to reduce the severity of a microprocessor failure, a relay-based by-pass system was integrated into the microprocessor controls. Bypass is accomplished by programming the microprocessor to store two binary bits of data upon power-up in special output port positions. If an incorrect value is stored in either of those positions, the back-up system begins its sequence; otherwise the microprocessor is assumed to be working and the relay bypass will be held inactive by holding the FAIL line high. If the "not fail" line in Figure 4 stays low, the bypass system engages. First, power is sent to furnace F2 through relays R10 and R12; R12 opens this circuit after 10 minutes. As the bypass system engages, power is also put to delay relay R8, which closes after 2 hours to put power to furnace F1; relay R11 opens

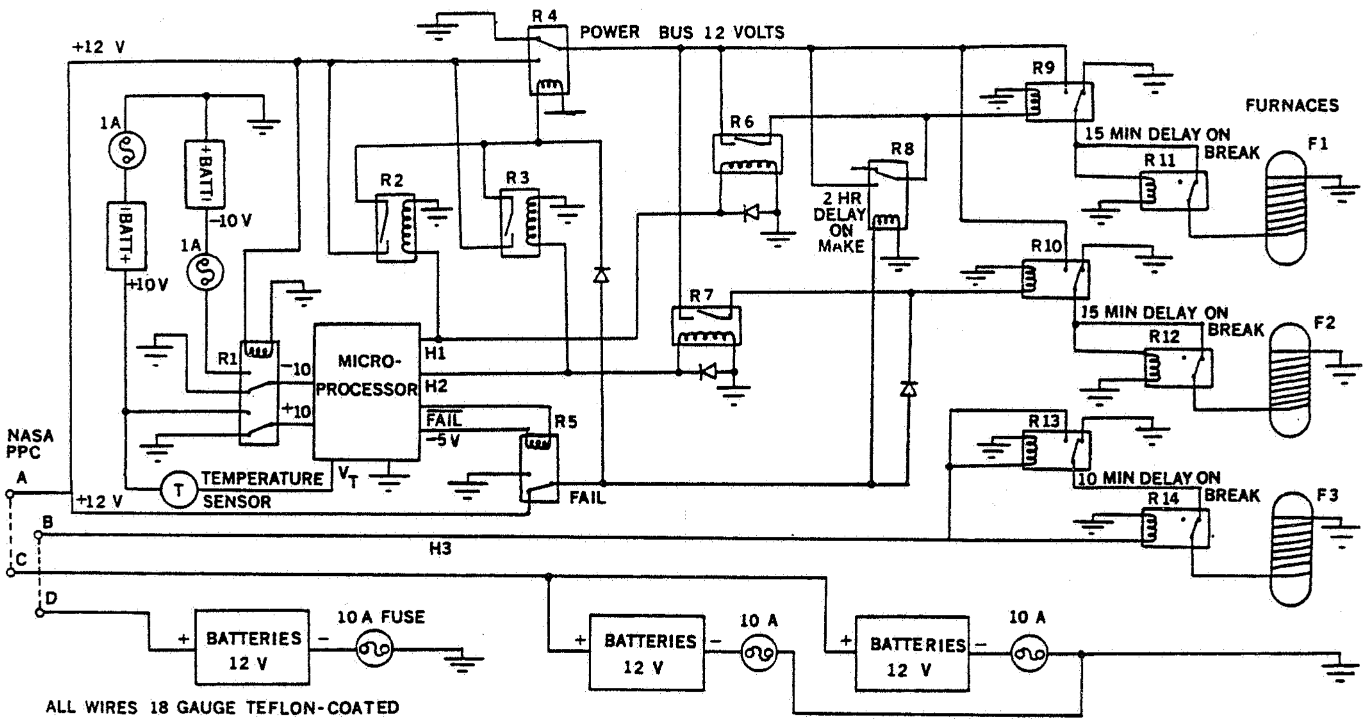


Figure 4. Overall electrical schematic, including furnaces. R3, R4, R6, and R7 are reed relays. R5 is low current bypass activation relay. R1 is low current microprocessor activation relay.

this circuit after 12 minutes. Delay relay R8 allows for battery recovery in the interval between running furnace F1 and furnace F2.

Furnaces and Foaming Apparatus. In order to melt the alloys, vacuum furnace assemblies had to be built which could reach at least 650 C. Nickel-chromium resistance heating wire (ribbon) having 1.3 ohms/ft was used. A schematic showing the vacuum furnace assembly is shown in Figure 5. Furnaces were sized to draw about 7 amps and to reach 650 C in approximately 8 minutes.

The actual alloy samples are pellets of approximately 1cc volume placed inside glass I-beam shaped channels; quartz glass was used for its high-temperature durability. Around the quartz was wrapped the heating wire, which was itself encased in a 3/8" layer of furnace cement (#33 from Sauereisen Cements Co., Pittsburgh) in order to protect the coils and to increase the thermal efficiency of the furnace. This unit was then wrapped in Kaowool, an asbestos-free high-temperature fibrous material to act as a mechanical support as well as thermal insulation. At this point it was necessary to place the assembly inside a Pyrex ampoule which could be evacuated in order to insure non-oxidizing conditions during melting. Ampoules are hermetically sealed with Vac-Seal (Perkin-Elmer Vacuum Products, Eden Prarie, Minn.), a very low vapor pressure epoxy. The ampoule is then enclosed in its own 3"x3"x8" aluminum box, and

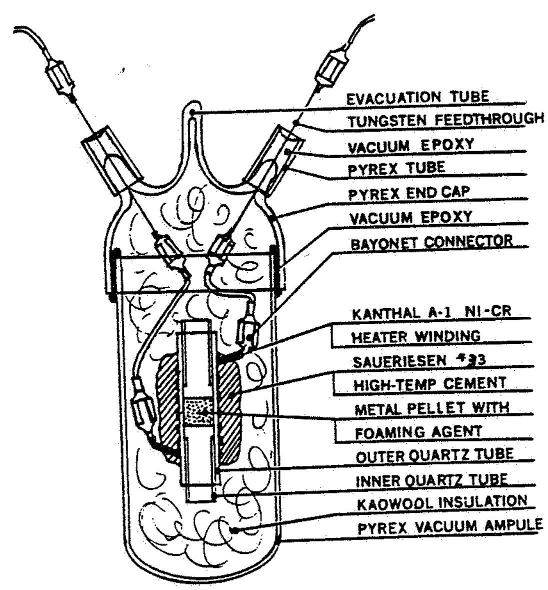
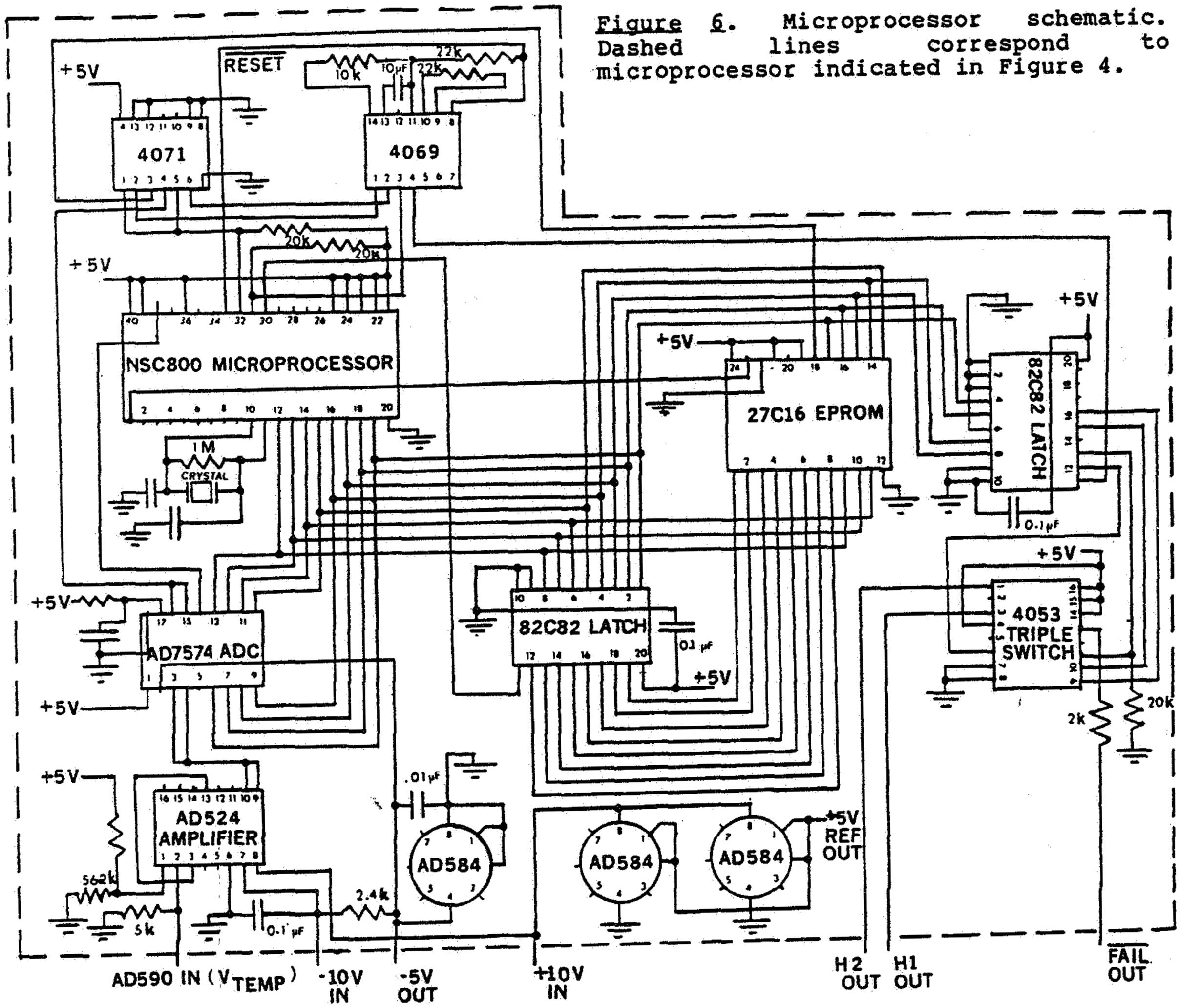


Figure 5. Furnace design, cross-section.



<u>Figure</u> <u>6</u>. Microprocessor schematic. Dashed lines correspond to microprocessor indicated in Figure 4.

packed with additional Kaowool. Because the battery voltage drops as a function of operating time, the furnaces consistently peak in temperature after 7-8 minutes at approximately *650* C, so that even if power is never shut off these maximum temperatures are not exceeded.

<u>Metallurgy</u>. To cause foaming, magnesium carbonate or manganese carbonate was mixed into the alloys while they were held near their eutectic temperatures (about 433 C). This mixture of alloy and carbonate was then cast by asperation into a borosilicate glass tube to form the desired pellet. Foaming does not occur until the pellet is remelted and heated to over *500* C. Decomposable hydrides were not used due to the possible difficulties associated with the resulting hydrogen gas. Pellets and furnace ampoules were sized so that one atmosphere pressures inside the ampoules were not produced.

The Microcomputer

Having allocated approximately half the weight of the GAS canister to the batteries needed for the experiment, it is not feasible to consider additional batteries for use in warming the entire payload. Instead, a microcomputer system controls furnaces F1 and F2 based on the measured battery temperatures. Power-up on the microcomputer occurs when the PPC switch is closed, thereby closing relay R1 (figure 1).

The control system schematic is shown in Figure 4. This microcomputer could be viewed as a general purpose, compact, low cost, low power, dedicated, programmable controller for space applications. Sufficient detail is provided so that the reconstruction of this microcomputer by other GAS groups should be straight forward. It is flexible and general enough to recieve a multitude of electrical inputs (e.g. accelerations, pressures, displacements), as well as generate several types of electro-mechanical outputs (such as control of servo-motors, valves, and tape recorders) through expanded use of the I/O ports available.

Hardware. Figure 6 details the hardware layout of the microcomputer. A temperature sensor sends an analog signal to the Temperature Sensor Interfacing components. These components amplify and bias the temperature signal and convert it into an eight bit digital signal. This digital signal is sent to the microprocessor via an eight bit data bus. The data bus also receives data from one EPROM memory chip. This data is accessed by a nine bit address bus. Four bits of the data bus are used to send signals to the Relay Interfacing components. These components control the activation of the power relays that switch power to the furnaces. Control signals, generated by simple logic gates, control the activation of the input port, the output port and the EPROM.

The main components of the microcomputer are a National Semiconductor NSC800 CMOS microprocessor and 27C16 CMOS EPROM memory chip. These IC's consume very little power, a great advantage since the microcomputer will need to operate for up to 27 hours. The microcomputer control system requires only 15 mA at +7.5 to + 20 volts and 4.0 mA at -7.5 to -20 volts. The power is implemented through the use of one and one half pounds of alkaline batteries that are rated at ten times the required capacity (so that continuous power for 27 hours is insured even at -40 C). Initially, the microcomputer batteries will supply the control system with +12 V and -15 V. However, during the course of the 27 hours in which the payload is activated, the supply voltages may drop to values as low as +8.5 V and -8.5 V (depending on the cargo bay temperatures and on the initial charge state of the batteries). For convenience, the microcomputer power supply voltages are labeled in all figures in this report as +10 V and -10 V.

Since all digital logic is based on mil. spec. voltage references (Analog Devices AD584's) which have a minimum supply voltage of 7.5 V, functional operation is insured for the entire expected range of the power supply voltages. In addition, these microprocessor components offer the following advantages:

(1) They have ample memory and I/O addressing capabilities.

(2) They have more than adequate speed. (the maximum expected rate of temperature change of the contents of the GAS canister is about 1.5 C per hour.)

(3) There is ample literature, software, and hardware support for these and similar components available.

(4) Industrial specification versions (operating at temperatures down to -40 C) of these chips are available at reasonable costs with short delivery times. Although military versions of these and other components are avilable with operating temperature ranges extending to -55 C, the high cost and long delivery times of these components made them infeasible.

The NCS800 microprocessor is operated with a 102 kHz crystal. This small frequency is employed in order to conserve power. One Harris Corporation 82C82 CMOS latch serves as a demultiplexer for the microprocessor's multiplexed address/data bus. The 4071 and 4069 chips are CMOS logic gates used for debouncing the RESET IN signal and generating simple control signals.

Temperature Sensing. The main component of the temperature sensing apparatus is an Analog Devices AD590 temperature transducer that is located in the power battery stack. This device produces a current that is directly proportional to the temperature of the power battery stack in degrees Kelvin. Since each degree K corresponds to 1 micro-amp, passing this current through a 5 K resistor causes the voltage across this resistor to vary 5 mV per K. This voltage is input to an instrumentation amplifier that is biased by 1.050 V on its inverted input. The output of this amplifier is input to an Analog Devices AD7574 analog to digital converter with a -5V reference. The resulting eight bit digital output covers a range from -63 C to +37 C, thereby extending well outside the expected temperature extremes. The accuracy, both theoretical and experimental, is within 1 degree C.

Analog to digital conversion is initiated by any I/O read. This will cause the AD7574's BUSY pin to go low, forcing the microprocessor's WAIT pin low and generating a NCS800 wait state. Since the AD7574 has a tri-state microprocessor compatable output, the digital output of the ADC is connected directly to the NSC800's data bus. The use of a high impedence device such as an instrumentation amplifier is essential because the analog to digital converter has a relatively low input impedence that is sensitive to temperature.

Relay Control Interfacing. All of the relay control signals are latched from the NSC800 data bus by an 82C82 eight bit latch. Since this is the only output port and since no RAMs are used, the microcomputer will write to this port exclusively. The output signals of this latch are buffered by a 4053 CMOS triple switch that drives four Magnecraft W107DIP-2 reed d.i.p. relays. These reed relays switch the 150 mA necessary to drive the coils of the power latching relays that supply 6 A to the furnaces.

Software. The microprocessor control system has two primary functions:

1. To activate furnaces F1 and F2 for a temperature dependent amount of time in a sequential manner with a 1/2 hour pause in between to allow for battery recovery.

2. To begin this heating sequence at an optimum time.

The first primary function presents no problem; the second one depends upon relative changes in payload temperatures and therefore requires temperature sensing as well as calculations of temperature gradient.

The rated capacity of the batteries is attained at approximately 25 C, and the available energy drops off markedly at temperatures below 0 C. Tests indicate that at temperatures below -19 C, the batteries may not have enough capacity to heat the furnaces to over 600 C.

According to the GAS Thermal Design Summary, internal temperatures are estimated at between -20 C and 0 C for most of the mission (assuming the payload is properly insulated). Two criteria are used for establishing the optimum time to activate the heating sequence: First the temperature must be above -19 C and second it must be falling. In this way if the experiment is activated when the top of the shuttle is facing the sun, the microcomputer will wait until the maximum temperature is reached (and the batteries will attain maximum capacity) before it activates the furnaces. If after 12 hours the temperature remains below -19 C, a low temperature heating sequence is activated unconditionally. This low temperature sequence applies power to the first furnace (F1) for a longer time than in the normal sequence in the hope that at least one alloy will receive enough energy to properly melt.

Upon astronaut activation of the experiment, the control system will first set all the relay outputs to a logic level zero. At the same time it will set the "not fail" line high, disengaging the bypass system. Next the microprocessor system will begin sampling the temperature. The microprocessor receives temperature information in the form of an eight bit binary number, TNEW. If TNEW is less than 0 F, then the microprocessor will continue to monitor the temperature until either TNEW rises above 0 F or until 12 hours elapse, causing activation of the low temperature heating sequence. This sequence consists of battery power being supplied to the first furnace for 9.5 minutes, a 30 minute pause and then battery power diverted to the second furnace for 13 minutes.

If, however, the temperature does rise above 0 F during the first 12 hours of activation, the control system will seek the maximum temperature. The microprocessor looks for a significant temperature drop as its indication that temperature has peaked. While the temperature is rising, the current temperature (TNEW) is continually stored in a register and referred to as TOLD. While the temperature is falling, TNEW is compared with TOLD (the maximum temperature thus far). If TNEW drops below TOLD by more than 3 degrees F, or if at any time TNEW rises above 19 C, or if the temperature continues to rise or remain steady for a period of 12.5 hours, the high temperature heating sequence is carried out. This sequence consists of power being supplied to the first furnace for 8.5 minutes, a 30 minute pause and then power is switched to the second furnace for 10 minutes.

The program was written in Intel 8080 assembler pneumonics and hand assembled into machine language. It occupies 218 bytes of ROM and requires no RAM.

Conclusion

The intent of this project is to demonstrate that ultralight, reactive metal foams can be produced directly as structural, I-beam shapes in a zero gravity environment. The design of the payload needed to accomplish this goal is given in detail. A lightweight computer that may be useful in other GAS payloads is also described in sufficient detail that its duplication by other interested groups should be straightforward.

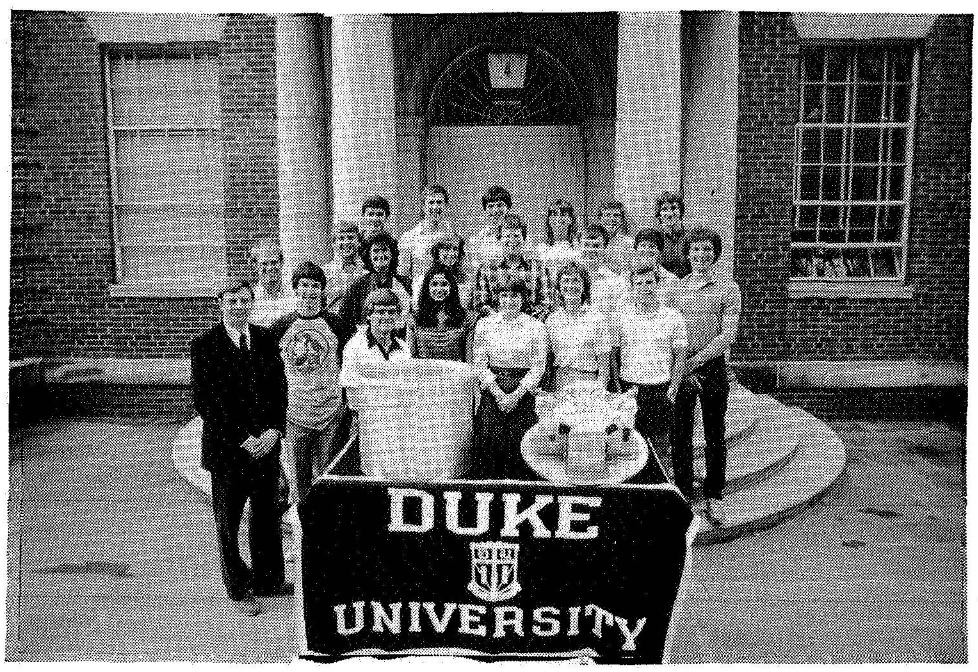


Figure 7. GAS 286 design team. Payload is displayed on table.

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AN EXTREME ULTRAVIOLET SPECTROMETER EXPERIMENT
FOR THE SHUTTLE GET AWAY SPECIAL PROGRAM

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ABSTRACT

An extreme ultraviolet (EUV) spectrometer experiment developed as a Get Away Special (GAS) payload for the Space Shuttle operated successfully on June 20, 1980 during the STS-7 mission. The objective of the experiment is to measure the global and diurnal variation of the EUV airglow. The spectrometer is an f 3.5 Wadsworth mount with mechanical collimator, a 75 x 75 mm grating, and a bare microchannel plate detector providing a spectral resolution of 7 Å FWHM. Read-out of the signal is through discrete channels or resistive anode techniques. The experiment includes a microcomputer, 20 Mbit tape recorder, and a 28V, 40 Ahr silver-zinc battery. It is the first GAS payload to use an opening door. The spectrometer's 0.1 x 4.2 deg field of view is pointed vertically out of the Shuttle bay. During the STS-7 flight data were acquired continuously for a period of 5 hours and 37 minutes, providing spectra of the 570 Å to 850 Å wavelength region ofthe airglow. Five diurnal cycles of the 584 Å emission of neutral helium and the 834 Å emission of ionized atomic oxygen were recorded. The experiment also recorded ion events and pressure pulses associated with thruster firings. The experiment will fly again on Mission 41-F scheduled for August 1984.

INTRODUCTION

Observations of the earth's ultraviolet airglow from rockets and satellites have been carried out for more than twenty years and the interpretation of these measurements has played an important role in our understanding of the upper atmosphere. However, it is only during the last few years that the airglow spectrum in the EUV wavelength region, below 1200 Å, has been measured spectroscopically (Ref. 1, 2, 3, 4). It is now known that the EUV spectrum is dominated by the emission lines of neutral and ionized nitrogen and oxygen atoms. These lines result either from the absorption of sunlight directly or from collisions with energetic photoelectrons.

As part of a program to develop continuous global monitoring of the ionosphere, our group at the Naval Research Laboratory is actively developing both the flight instrumentation and the theoretical models necessary to measure and analyze ionospheric emissions from earth orbit. An EUV spectrograph has been developed as a Shuttle GAS payload (Ref. 5,6). It was successfully flown on STS-7, launched on June 18, 1983 and is scheduled to fly again on Mission 41-F in August, 1984. Called the Space Ultraviolet Radiation Environment experiment (SURE), the experiment is sponsored by the Air Force Space Test Program. It was the first GAS payload to utilize the opening lid with the standard GAS cannister and was also the first EUV spectrometer experiment to operate on the Space Shuttle.

The scientific objectives of the SURE experiment are to obtain EUV spectra of the earth's airglow and to measure its global and diurnal variation. By modelling the interaction of the atmosphere with sunlight and comparing the results with the SURE data we obtain a better understanding of the variations of the densities of atoms, molecules, ions and electrons that constitute the region above an altitude of 100 km.

THE INSTRUMENT

The Spectrograph

The spectrograph consists of a mechanical collimator, a concave diffraction grating with a radius of curvature of 50 cm, and a bare microchannel plate (MCP) detector. These elements are arranged in a Wadsworth configuration with an instrumental f/number of 3.5, and the instrument is operated in first order. The light path is shown in Figure 1. The collimator is assembled from fifteen molybdenum grids 75 mm square with vertical slits 0.0075 inches wide separated by 0.005 inches. The grating is also 75 mm square, and its spherical surface was holographically ruled to a density of 4800 grooves/mm. The

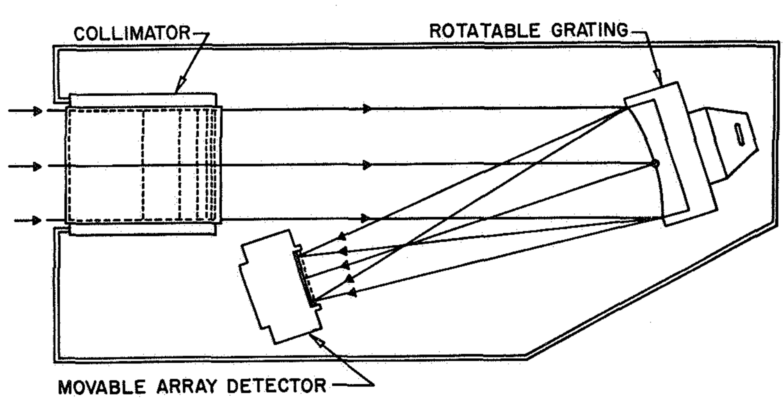

Figure 1. Light path for the SURE spectrometer.

spectral coverage of the instrument is determined by the 2 x 3.46 cm size of the active area of the detector which is positioned to intersect the focal curve of the grating. Since the plate factor of the spectrograph at 640 Å is 8.1 Å/mm, a band pass of 280 Å is imaged on the front plate of the detector. In order to increase the spectral coverage the instrument can be operated in either of two modes with different angles of incidence. Changing modes is accomplished using a stepper motor to rotate the grating-detector assembly in the dispersion plane while translating the detector to maintain focus. The two modes give a coverage from 570 to 850 Å and from 810 to 1080 Å. The spectral resolution is determined by the divergence from a single angle of incidence of the light beam passing through the collimator. Preflight measurements in the laboratory and flight data indicate a resolution of 7 Å. The field of view of the instrument was measured in the laboratory to be $\pm$ 0.1^{o} by $\pm$ 4.2^{o}.

The Detectors

The detector used for the STS-7 flight consists of two 40 mm MCP's stacked in a tandem or chevron configuration and proximity focussed on an array of 128 anodes, each measuring 0.260 x 200 mm and separated by 0.010 mm. These components and the signal cable connectors are permanently mounted in an aluminum barrel. The charge collected by each anode is processed by a separate, minature, hybrid amplifier/counter circuit. The electrical connection to the MCP's put 1100 V across each plate and held the front plate at - 2800 V. No photocathode or filters were used. In order to prevent ions from entering the spectrograph and being attracted by the detector surface, all outgassing ports were covered by multiple-reflection caps.

This discrete-anode detector has subsequently been replaced by a two-dimensional resistive anode device and position determining electronics purchased from Surface Science Laboratories. As before, two MCP's are stacked in a chevron arrangement. However, the MCP's are biased so that the front plate is at ground and the anode is at +2400 V. In addition a fine nickel mesh is mounted in front of the MCP's and kept at -100 V to repel stray electrons and collect ions. During flight the collimator will be floated at +28 V to form a trap for ions which otherwise may stream into the spectrograph.

The Calibration

The instrument performance was characterized in the laboratory before flight using a variety of windowless discharge light sources. The relative channel-to-channel response of each of the detectors was measured by illuminating the detector through a 0.260 x 20 mm slit and moving the slit across the face. The full detector was also illuminated with diffuse light. The two measurements together characterize the flat-field response which must be divided into every spectrum. The relative response as a function of wavelength was measured by viewing a collimated, monochromatic beam with the instrument and comparing the resulting count rate with that of a calibrated reference channeltron detector. Finally, the absolute responsivity was measured by viewing an illuminated diffuser screen of aluminum-coated ground-glass with both the instrument and the reference channeltron. The screen was illuminated with He, Ne and Ar discharges and the resonance line emissions (He 584.3, Ne 743.7, Ne 735.9, Ar 1048.2, and Ar 1066.7) were observed. The measured responsivity of the instrument with the discrete anode detector, was 1.3 counts s^{-1} R^{-1} at 584 Å, 1.0 count s^{-1} R^{-1} at 834 Å in the short wavelength mode, and 0.2 counts s^{-1} R^{-1} at 1000 Å. The uncertainty of the absolute calibration is estimated at $\pm$ 30%.

Characterization of the resistive anode detector followed a process of baking in a vacuum for 48 hours and scrubbing with Ly α light. The plate voltages were set just below the levels at which the MCP's became noisy. These levels were found to increase over several days. The final voltages were set when the sensitivity was found acceptable and were not increased futher because of uncertainties in the pressure levels to be expected once the Shuttle arrives on orbit. The dark count of the detector is consistently between 5 and 10 counts s^{-1} over the whole 1250 mm^2. Figure 2 shows the measured flat field response. We did note that when total count rates exceeded 5 x 10^4 counts s^{-1} the flat field changed shape and became more peaked toward the center. Many of the emissions present in the EUV airglow of the upper atmosphere are produced from a discharge in a mixture of 10% O_2 in He. Figure 3 shows a spectrum of this discharge taken in the laboratory with the instrument using the resistive anode detector. The wavelength scale was determined by performing a least squares fit to the features identified in the figure as well as the rare gas resonance lines.

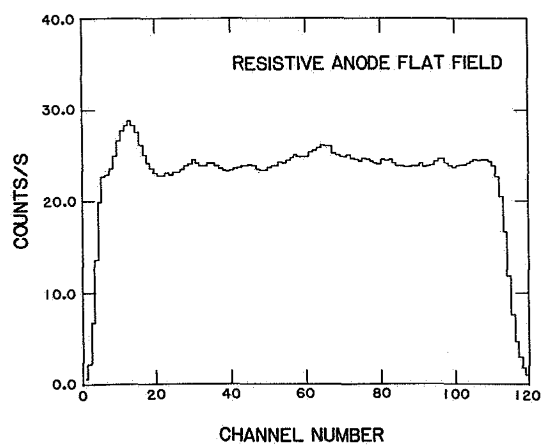

Figure 2. Flat field response of resistive anode detector.

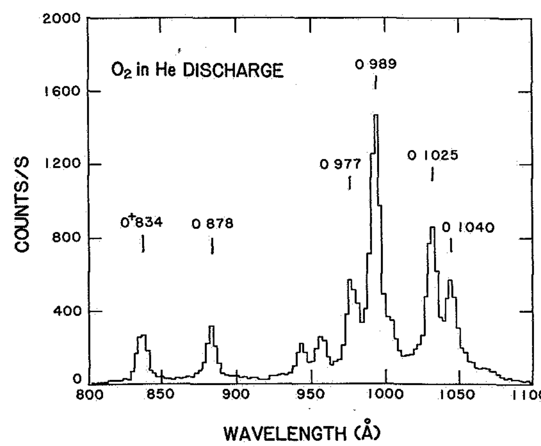

Figure 3. Laboratory spectrum of O_2 and the discharge measured with SURE spectrometer and resistive anode detector.

DATA AND POWER SYSTEMS

The operation of the SURE experiment, after it is powered up on orbit, is controlled by a Motorola 6800 microcomputer. Figure 4 is a block diagram showing the components of the computer and its interfacing to the experiment. The read-only memory contains the controlling program. When the experiment is active, data is temporarily stored in random-access memory (RAM) and periodically recorded on magnetic tape by the experiment tape recorder. The computer also performs regular health checks, including monitoring component temperatures, checking for the sun near the field of view, and recording voltage and current levels.

The degree of involvement of the processor in the photon-counting process depends on the detector electronics. The discrete-anode electronics includes a counter for each channel so the processor simply reads the counters at the end of every integration period (typically about 5 sec.). On the other hand, the resistive-anode electronics signals the processor each time a pulse position is encoded. The processor then must read the coordinates of the pulse and increment the corresponding pixel address in memory. The time required to execute the necessary code becomes an important part of the instrument dead-time.

The experiment tape recorder is the SETS-I manufactered by Sundstrand Data Control, Inc.. It is a four track recorder with a capacity of 20 Mbits. The recorder and its controller electronics are housed in a hermetic box measuring 12 x 13 x 25 cm. The data link between the controller and the experiment microcomputer uses a synchronous communications port.

Experiment power is provided by a battery constructed from 19 silver/zinc wet cells, each providing 40 Ah at 1.5 V. The battery is housed in a vacuum box measuring 32 x 22 x 22 cm and, when assembled, weighs 125 kilograms. Despite the delay of more than two months between the final charging and launch, very little charge depletion occurred.

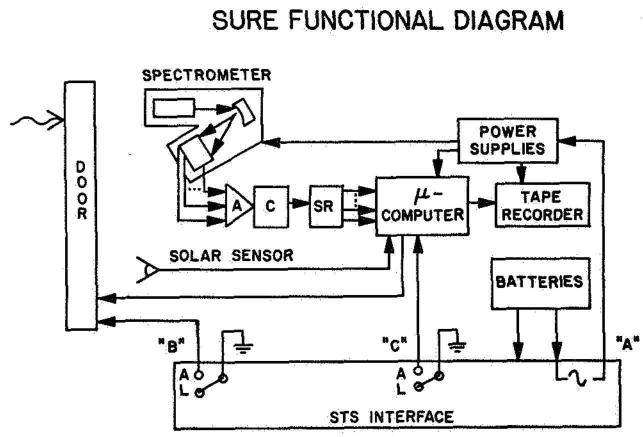

Figure 4. Block diagram of SURE control and data handling.

GET AWAY SPECIAL SUPPORT SYSTEM

Motorized Door Assembly MDA

The EUV airglow is extremely faint and there are no window materials which transmit efficiently at wavelengths below 1050 Å. For this reason opening of the MDA on orbit directly exposes the SURE experiment to the Shuttle environment. The power to drive the door mechanism is drawn from batteries which are part of the NASA equipment; however, the experiment must provide power to a relay which enable the drive. Therefore when the experiment is active it has control over the door, but the door always closes when the experiment is deactivated. The SURE experiment opens the door immediately following activation and closes it only after it has completed its observing program. This is both to assure minimum pressure levels in the cannister and to prevent overheating.

GAS - User Interface

The electrical interface between a GAS payload and GAS interface to the Shuttle system includes:

1) power - all experiment power is routed through the Payload Power Contactor on the GAS Interface Equipment Plate (IEP). This gives the Shuttle system absolute control of experiment power - a requirement demanded by the overriding issue of safety on a manned mission.

2) commands - there are three latching relays whose states can be used by the payload to provide commands. One of those is dedicated to payload power control so the two states of the remaining two relays can be used for experiment control by the Shuttle crew.

3) door control - the interface allows the payload to activate the Motorized Door Assembly (MDA) and monitor the door position.

4) test connections - payload test points are passed through the IEP in order to provide Ground Support Equipment (GSE) access to the payload.

The SURE detector requires pressure levels less than $1x10^{-5}$ Torr. Higher levels cause the detector to become noisy and pressures above $1x10^{-4}$ can permanently damage the microchannel plates. In order to assure that the interior of the GAS cannister reaches operating levels as quickly as possible after the door has opened on orbit, the payload is kept clean and dry during integration and a 3 inch pumping port was added to the IEP to permit the cannister to be pumped following integration.

Crew Interaction

The use of a microcomputer as an experiment controller allows the observing program of the SURE experiment to be tailored to the mission time line for almost any flight. Once the periods of favorable operating conditions have been identified, the controller program can be optimized. Data can be acquired in a single 18 hour period or partitioned into as many as four shorter periods. Commands to the payload are sent by the crew using the Autonomous Payload Controller (APC). The experiment requires the following commands: 1) activation - this powers up the experiment computer and opens the door, 2) mode selection - this initiates data acquisition and 3) deactivation - this turns off the experiment and closes the door.

Postflight Pointing History

Unlike other GAS payloads, SURE is an optical experiment acquiring geophysical data. It is critical to the interpretation of those data that we are able to identify the orientation of the field of view and its geographic location for every spectrum. Although this information is not routinely provided to GAS experimenters it may be available in the Postflight Attitude and Trajectory History (PATH) products.

The SURE experiment uses the vectors to the sun and to the earth to determine solar illumination conditions, and the orbiter state vector referred to the Greenwich meridian to determine longitude, latitude and attitude. These vectors are available at 10 second intervals with accuracies of 0.2 degrees.

RESULTS OF THE STS-7 FLIGHT

The SURE experiment was integrated with the GAS equipment on March 29, 1983. It was installed aboard the challenger orbiter in late April, 1983 for the STS-7 mission, and launched on June 18, 1983. The activation command was issued at Mission Elapsed Time (MET) 1/05:40 (day/hours:minutes). At MET 2/08:17 the experiment was commanded to start taking data and was deactivated at MET 3/05:50. The crew confirmed that the door opened and closed as scheduled. Figure 5 shows the experiment and door during integration and Figure 6 is a photograph from the aft flightdeck showing the payload with the door open during the flight. The experiment was aligned so that the long axis of the field-of-view (0.1^{o} x 4.2^{o}) was nearly parallel with the long axis (x-body axis) of the orbiter and viewed directly up and out of bay. Except for short periods of Inertial Measurement Unit (IMU) alignments, the orbiter was in the bay-to-earth (-ZLV) attitude during the SURE observations.

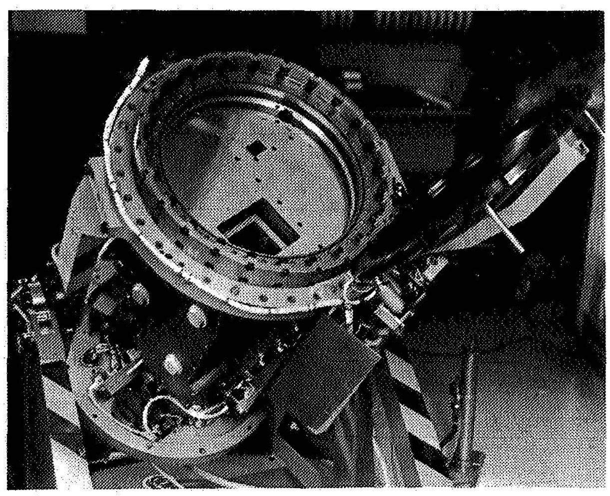

Figure 5. SURE mated with door assembly and interface equipment during integration.

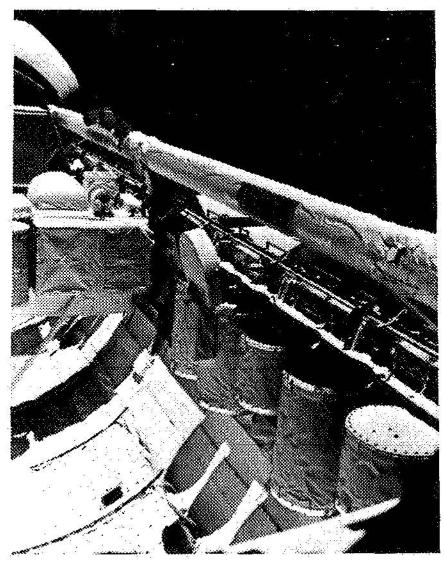

Figure 6. SURE with open door during STS-7 mission.

The Dayglow

The emissions which comprise the EUV dayglow are primarily either the direct result of the absorption of sunlight by the neutral atoms and molecules in the earth's upper atmosphere (above an altitude of 100 km) or the result of collisions with photoelectrons - the energetic electrons formed when sunlight is absorbed. In the wavelength region below 850 Å, two of the brightest dayglow emissions are the line at 584 Å due to resonant scattering of sunlight by atmospheric helium, and the set of three lines around 834 Å resulting from the ionization and excitation of atomic oxygen by fast photoelectrons. The oxygen emission (called O^{+} 834 Å), is particularly important as a diagnostic tool for characterizing the ionosphere (ref. 7). Understanding the intensity of this emission is complicated because although the initial excitation and emission takes place at altitudes around 135 km, the free O^{+} which constitutes the ionosphere at higher altitudes (above 300 km) is very efficient in scattering the radiation and forms a kind of fog layer at shuttle altitudes which is brightened by the illumination from below. Extensive modelling is required to disentangle the physics of this emission but it promises to be very important to global monitoring of the ionosphere.

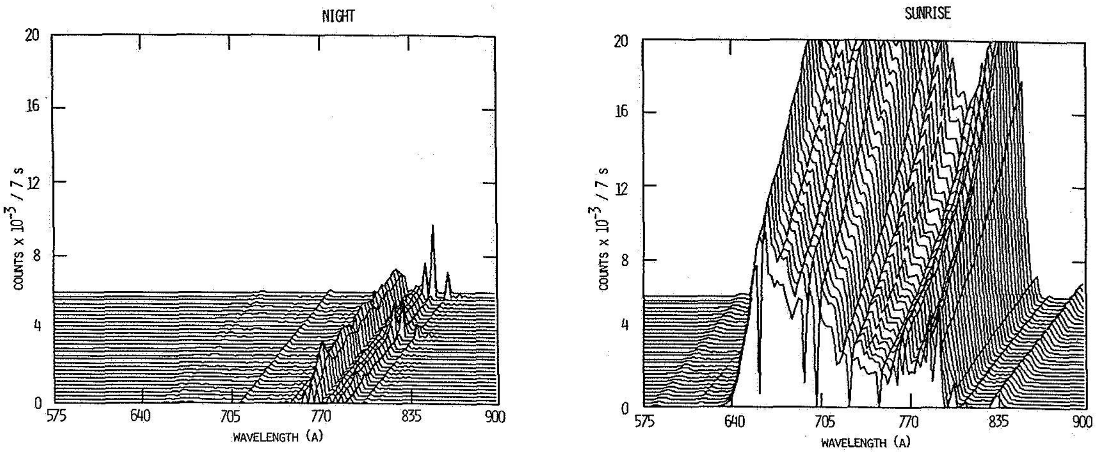

Figure 7. Time series of spectra from STS-7 mission. Series on left is night data and series on right is recorded just after sunrise. Each spectrum is integrated for 7s.

Two sets of spectra are shown in Figure 7. The set on the left is a time series taken at night and the set on the right is a series shortly after sunrise. Each spectrum is integrated for 7 seconds. The night spectra demonstrate the inherent noise level of the detector and are similar to the preflight calibration data taken in the laboratory. The sunrise series clearly shows the He 584 Å and O^+ 834 Å features brightening as the solar zenith angle gets smaller. The very strong signal in the central region of the spectra is probably due to ions which were allowed to enter the instrument as a result of the misconnection of the instrument's ion repeller. Post-flight simulation with an ion source produced very similar signals but did not achieve the flight levels. The edges of the detector (where the He 584 Å and O^+ 834 Å features are focussed) were protected from ions by a grounded aperture plate.

The experiment operated successfully for about five hours before the tape recorder controller apparently malfunctioned, causing the recorder to run continuously to the end of the tape. The recovered data samples five diurnal cycles of the helium and oxygen emissions and is of very high quality. Figure 8 compares the variation of the O^+ 834 Å emission and a simple theory which predicts the changes in the initial excitation efficiency in response to changes in the solar zenith angle. More detailed analyses are expected to yield information on the affect of winds in the upper atmosphere on the structure of the ionosphere.

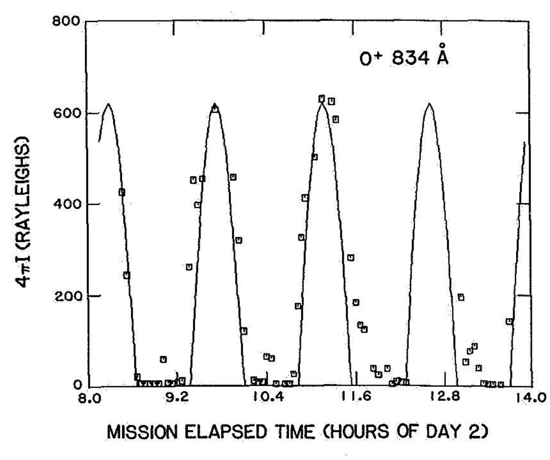

Figure 8. Diurnal variation of O^+ 834 Å emission compared to optically thin theory. Instrument was viewing the nadir.

Orbiter Environment

At the moment the experiment began taking data on the STS-7 mission, the orbiter was in the process of maneuvering for an IMU alignment. The field of view was swept from an earth viewing attitude, through the horizon and out into space. About 40 minutes later, when the orbiter was in darkness, the vernier thrusters were fired to begin the maneuver back to an earth viewing attitude. At the same moment the SURE detector saw an impulse of signal which is indicative of both increased ion densities and increased pressure levels inside the GAS cannister. The sudden onset of these signals is shown in Figure 9.

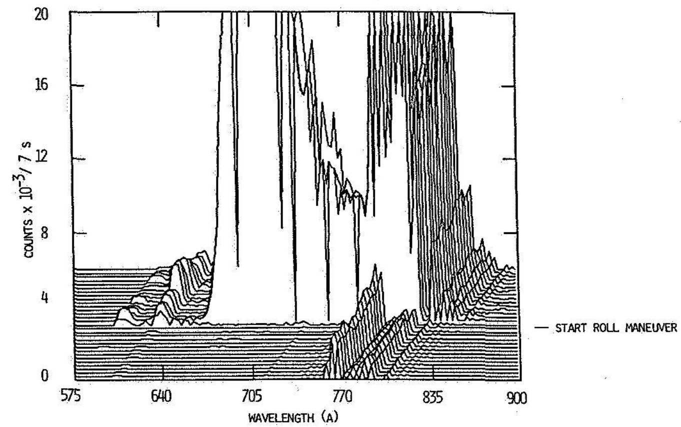

Figure 9. Sudden impulse of signal during the night coincident with start of orbiter maneuver.

These data point out the susceptibility of Shuttle experiments to the various contaminates created by orbiter systems. On the other hand we have demonstrated that high quality EUV spectra can be obtained from the Shuttle platform. Further analysis using the PATH data will provide information on the effects of regions of high particle flux such as the South Atlantic Anomaly.

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16. Abstract

The 1984 Get Away Special (GAS) Experimenter's Symposium will provide the first formal opportunity for GAS Experimenter's to share the results of their projects. The focus of this symposium is on payloads that have been flown on Shuttle missions, and on GAS payloads that will be flown in the near future.

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