THE SPACECRAFT THAT LANDS ON EARTH...

NEWS About Space Flight

...it comes from Rockwell International

Space Transportation System 41-D (STS-14)

SHUTTLE STUDENT INVOLVEMENT PROGRAM

A materials processing experiment, "The Purification and Growth of Single Crystal Indium by the Float Zone Technique in a Zero Gravity Environment," will fly on Space Shuttle mission 41-D.

Proposed by Shawn Murphy of Newbury, Ohio through the Shuttle Student Involvement Project (SSIP), the experiment seeks to demonstrate an advanced technique for producing unique semiconductor materials. The SSIP is jointly sponsored by the National Science Teachers Association and the National Aeronautics and Space Administration (NASA) to stimulate interest in science and technology by directly involving secondary school students in a space research program.

The Space Transportation Systems Division of Rockwell International is the industrial sponsor for Shawn Murphy's float zone experiment.

Shawn Murphy submitted his experiment to NASA in 1982 which was selected as an SSIP regional winner, then national winner, by panels of scientists, engineers, and educators in the areas of creativity, originality, scientific validity, appropriateness, organization, and clarity.

In December 1982, Rockwell International offered to become the industry sponsor for Shawn's project and to employ the company's newly developed laboratory-like Fluids Experiment

Rockwell International

OFFICE OF PUBLIC RELATIONS

FEA-1 MISSION

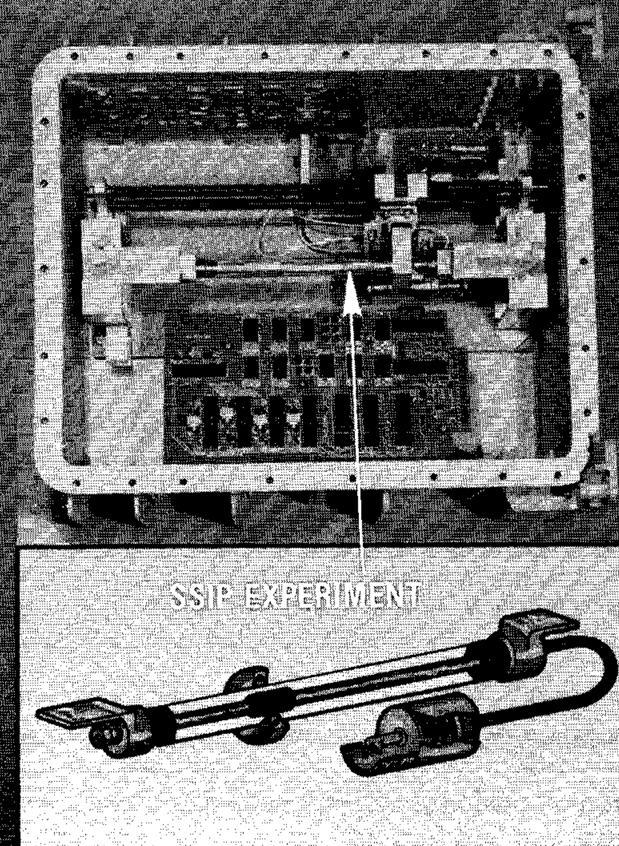
"THE PURIFICATION AND GROWTH OF SINGLE CRYSTAL INDIUM BY THE FLOAT ZONE TECHNIQUE IN A ZERO GRAVITY ENVIRONMENT"

OBJECTIVES

- FLIGHT TEST THE FEA
- DEMONSTRATE THE PROCESSING TECHNIQUE
- STUDY THE MATERIAL PROPERTIES
- INVESTIGATE PROCESS BENEFITS & LIMITATIONS

ANTICIPATED RESULTS

- IMPROVED CRYSTAL QUALITY & DOPING UNIFORMITY
- PROCESS LESS DEPENDENT ON MATERIAL PROPERTIES
- KNOWLEDGE ABOUT:
  - FLOAT ZONE LENGTH EFFECTS
  - SURFACE TENSION (MARANGONI) EFFECTS
  - MICRODYNAMIC/THERMAL ENVIRONMENT SENSITIVITY
  - THERMAL GRADIENT/GROWTH RATE (G/R) EFFECTS
  - MANUAL EXPERIMENT CONTROL SUITABILITY



IMPROVED SEMICONDUCTORS — SIMPLER SYSTEMS

- VERY LARGE/HIGH YIELD INTEGRATED CIRCUITS
- HIGH PERFORMANCE DETECTORS
- ADVANCED MICROWAVE DEVICES

Apparatus (FEA) to house the experiment on a Shuttle mission. Rockwell International's obligations have included assisting the student investigator prepare the flight sample, integrating the experiment into the FEA and the FEA into the Shuttle, preparing the launch agreement and other official documentation, mission planning, and astronaut crew training. Rockwell International will provide technical support during the mission from NASA's Johnson Space Center and will assist Shawn in analyzing the experiment sample at Rockwell International's Science Center following the mission.

This experiment will be the first to use the FEA and consequently this FEA flight is designated FEA-1. The FEA is located in the crew compartment mid-deck. The FEA is a modular zero gravity chemistry/physics laboratory designed to conduct basic and applied research in the areas of general liquid chemistry, fluid physics, thermodynamics, crystal growth, and biological cell culturing. To perform this float zone experiment, the FEA has been configured with an annular heater that can be driven along a cylindrical sample. The sample is enclosed in a glass tube and the space between the sample and tube is filled with an inert gas. FEA instrumentation will monitor, display, and record experiment parameters such as sample temperature, gas pressure, and heater power and motion.

Floating zone techniques are used to refine materials and to grow large single crystals. The process works by positioning an annular heater around, but not in contact with, a cylindrical sample and melting a short zone of material. The heater is then translated along the sample, melting the solid material ahead of it while the molten materials behind it refreezes. Purification of the sample take place when impurities, which may be distributed through the original sample, are held in solution in the molten zone as it passes through the sample. The impurities eventually end up at one end of the final sample when the liquid zone reaches this location and is allowed to solidify when the heater is switched off. Single crystal growth occurs when the initial zone melting is located at the interface between the original polycrystalline sample and a single crystal "seed." As the heater moves away from the seed, the portion of the molten zone in contact with the seed crystal solidifies with the same crystallographic lattice structure as the seed's.

On Earth, the application of float zone processing is severely limited because the liquid zone cannot be maintained in a gravity environment. If the material's density is too high or surface tension is too low, the fluid will simply spill. Thus, restricting use of this technique to only a few of the many candidate materials with scientific and industrial interest. The weightlessness of space allows a stable float zone approximately three times its diameter, a length independent of material properties and longer than can be achieved with the few materials that can be processed in this manner on Earth. A longer zone allows greater control of thermal gradients at the crystal growth face and results in superior crystal quality. Purity and crystal quality are also enhanced by a lack of gravity driven convective stirring within the melt and the absence of a physical container (a potential source of chemical and thermal contamination) for the molten material.

This experiment will demonstrate the float zone process in zero gravity and evaluate the performance of the techniques utilized. The material properties of the single crystal will be examined and compared with similar material produced on Earth. The process benefits and limitations will be explored and should form a basis for industrial utilization. Shawn's project will be the first American sponsored float zone crystal growth experiment to fly in space.

The experiment sample is a one centimeter diameter by 15 centimeters long polycrystalline indium rod welded to a seed of single crystal indium. While single crystal indium has little industrial value, it is an excellent model material with which to investigate float zone processing technology because of its low 156 degrees Celsius (314 °F) melting temperature. The indium rod is doped with approximately 100 parts per million of thallium to serve as a measureable trace element to gauge crystal structure and material purity. An annular heater will melt a zone at the sample/seed interface and translate at a rate between 2.5 and four centimeters per hour. The molten zone length will be maintained at approximately two centimeters. An argon atmosphere at a pressure of approximately two pounds per square inch is maintained around the sample during the whole mission to keep the indium free from oxidation.

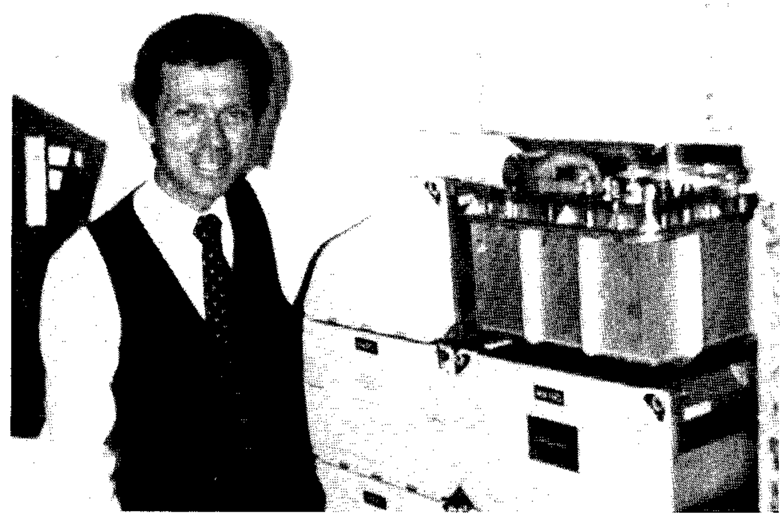
A demonstration of the float zone process in zero gravity where it will be less dependent on material properties is expected to be the most significant result. Improved crystal quality and better doping uniformity should also be achieved. Knowledge will be gained about float zone length effects, surface tension (Marangoni) effects, dynamic and thermal environment sensitivity and, thermal gradient and growth rate relationships.

The principal use for float zone processing is to manufacture high quality single crystals for semiconductors. Higher quality material should result in larger, higher density integrated circuits with greater production yield. Unique materials which cannot be produced on Earth promise higher performance electronic devices like detectors and microwave components. Large savings are anticipated at the systems level when more uniform, larger, higher density, and faster devices are used.

Shawn Murphy of Newbury, Ohio, is the student investigator for this SSIP experiment. A junior at Newbury High School when he submitted his proposal to NASA, Shawn graduated with the class of 1983 and is now 18 years old. He has completed his first year at Hiram College in Ohio. Shawn plans to attend Hiram for two more years before transferring to Boston College for two years to obtain a degree in criminology. Shawn worked at Rockwell on the preparation of his experiment and participated in the experiment design and safety reviews at the Johnson Space Center (JSC) during the summer of 1983. He will observe the Shuttle launch at the Kennedy Space Center (KSC) and support the mission at JSC. Shawn will analyze the experiment sample at Rockwell's Science Center after the mission before returning home to write his final report this summer.

Shawn P. Murphy

At Rockwell's Space Transportation Systems Division, the student experiment project has been the responsibility of Michael J. Martin who is working to develop space processing as a new business area for the company. His duties include informing nonaerospace industry about the opportunity to perform research in zero gravity, analyzing industrial requirements for space processing research, and developing the projects to meet those requirements. He is a member of the Space Processing Technical Committee of the American Institute of Aeronautics and Astronautics. Previously he was involved in various space manufacturing studies, including the identification of products that could be manufactured in space by Rockwell International.



Michael J. Martin

Mr. Martin has more than ten years experience in the design and analysis of electro-optical systems and components. During this time he specialized in optical design and the attenuation of stray radiation. He has worked for Rockwell International for thirteen years, including 3½ years at Electronics Operations in Anaheim, California.

Mr. Martin graduated from the University of California at Irvine in 1969, where he majored in engineering.

Rockwell's Space Transportation Systems Division project engineer for the FEA is James (Jim) J. Hendrick. Several years ago Jim became involved in research on space vehicles and experiment equipment for doing materials processing in space. This led him to define the concept for a small universal device, now called the Fluids Experiment Apparatus, which makes it easier and cheaper to do the initial phases of research for commercial space-manufactured products. The last two years have been devoted to designing and manufacturing the Fluids Experiment Apparatus and integrating into it the first experiment and coordinating its first flight with NASA's Johnson Space Center.

James J. Hendrick

Jim started at Rockwell (then North American Aviation) in 1957, as responsible instrumentation engineer for two Navaho missiles and boosters. Later, at the new Autonetics division, he was responsible for the Navaho instrumentation and telemetry package, and for several items of automatic guidance alinement ground support equipment. He then became responsible system integration engineer for guidance systems on Minuteman I, Polaris submarine, B-70, and others. Later, he managed groups which developed support system and equipment design concepts for those systems. His last responsibility at Autonetics was for program implementation and contractor and subcontractor interfaces for F-111 safety, reliability, quality, parts and materials.

Jim moved to the Space Transportation Systems Division where he was responsible for achieving a 12 year life for the proposed Grand Tour spacecraft. He conducted a number of research and contract studies dealing with Shuttle design, operations, payloads, data handling, and use of commercial equipment in space. He put together the rationale and system requirements which prompted NASA to decide to launch spinning satellites from the Shuttle, and defined the current standard payload-to-Shuttle multiplex-demultiplex module.

He received a BSEE from the University of Oklahoma.

Dr. M. David Lind of Rockwell International's Science Center Microelectronics Research and Development Center is the science advisor for this project. He has supported the experiment development and planning and will work closely with Shawn Murphy during the sample analysis following the mission.

Dr. Lind received his B.S. from Otterbein College in 1957 and his Ph.D. in Physical Chemistry from Cornell University in 1962. After one and one-half years of post-doctoral work at Cornell University, he was employed at the Union Oil Company Research Center from 1963 to 1966, and has been with Rockwell International since 1966. Dr. Lind's principal research interests are in crystal growth and x-ray crystallography. He has more than 30 publications in these fields. Dr. Lind has been Principal Investigator for crystal growth experiments in the Apollo-Soyuz Test Project, the Space Processing Applications Rocket Project, and the Long Duration Exposure Facility. He is a member of the American Physical Society, American Crystallographic Association, American Association for Crystal Growth, and Sigma Xi.

FLUIDS EXPERIMENT APPARATUS

The Fluids Experiment Apparatus (FEA) was developed and built by Rockwell International's Space Transportation Systems Division, Downey, California. The FEA is a zero-gravity chemistry/physics laboratory for use on the Space Shuttle to support space processing research in general liquid chemistry, fluid physics, thermodynamics, crystal growth, and biological cell culturing.

The FEA has the functional capability to heat, cool, expose to vacuum, and manipulate experiment samples which may be gaseous, liquid, or solid. Samples can be mixed and stirred in containers, or processed in a semicontainerless float zone mode. Multiple samples can be removed or changed during a mission. Instrumentation can measure sample temperature, pressure, viscosity, etc. A movie camera simultaneously records sample behavior and instrumentation data displays.

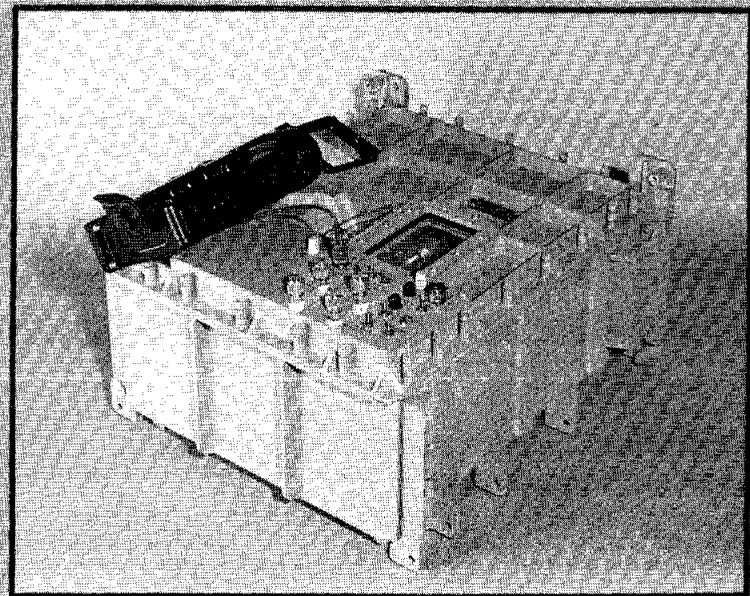
The FEA has interior dimensions of 472 by 368 by 187 millimeters (18.6 by 14.5 by 7.4 inches) and can carry 11 kilograms (26 pounds) of experiment unique hardware. It mounts in place of a standard stowage locker in the mid deck of the Shuttle crew compartment where it is operated by the flight crew. This installation and means of operation permit the FEA to be flown on most Space Shuttle missions.

The FEA's modular design permits it to be easily configured for almost any experiment. Optional subsystems can include fluid manipulation experiment containers, bulk fluid chemistry chambers, living cell incubators, multisample columns, and other user-specified hardware. The FEA uses 120 VAC 400 Hz power from the Shuttle orbiter and can be connected to the orbiter cooling system.

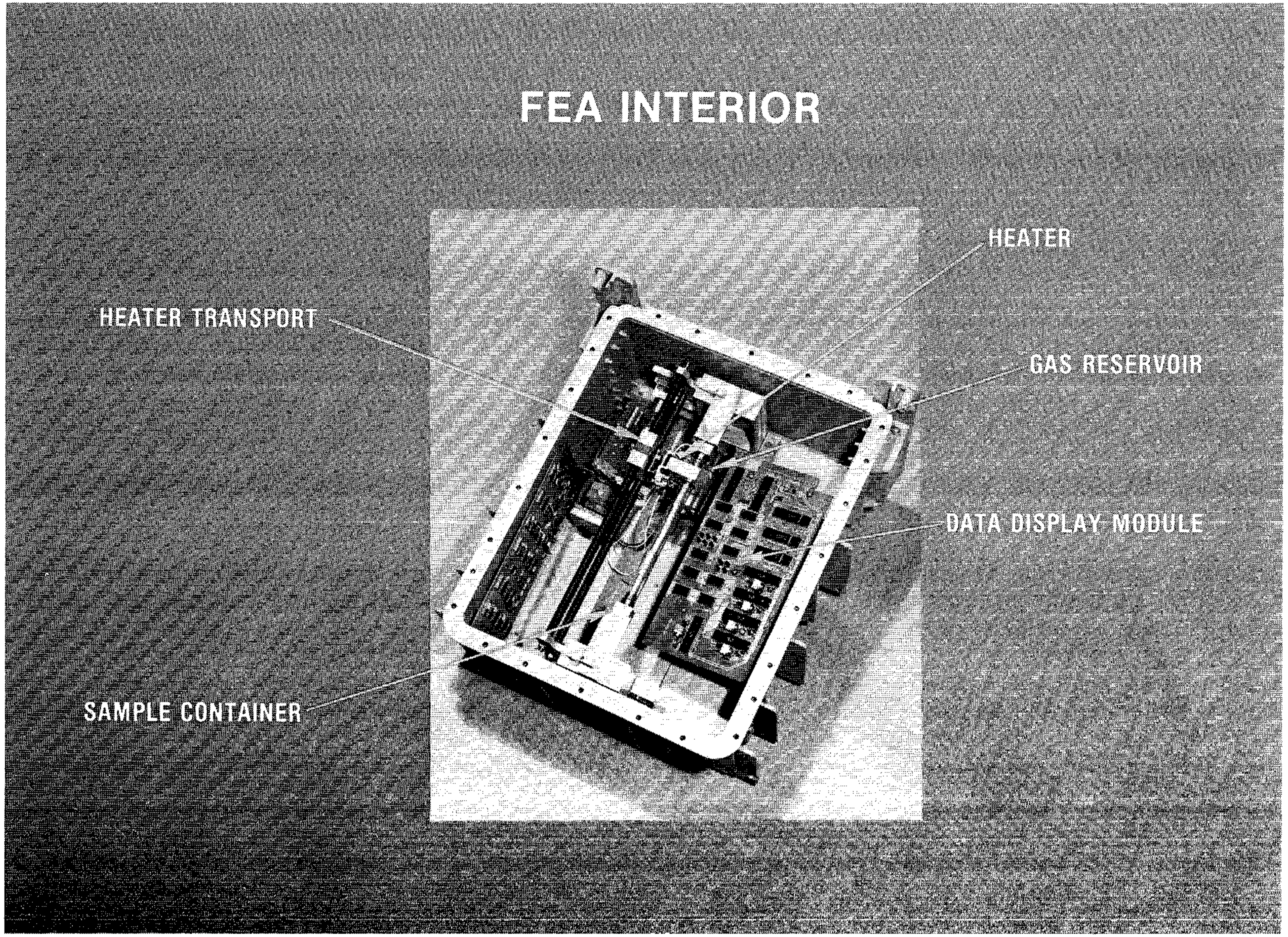
The FEA was developed in response to interest by nonaerospace industry in space processing research. Its design and operation have been thoroughly coordinated with potential industrial users, NASA materials processing specialists, and Shuttle operations personnel. The FEA can provide convenient, low cost access to space for basic and applied research on a variety of products and process technologies. Many of the FEA's key features will be demonstrated by performing the float zone crystal growth experiment on the FEA-1 mission.

FLUIDS EXPERIMENT APPARATUS (FEA)
MODULAR ZERO GRAVITY CHEMISTRY/PHYSICS LABORATORY

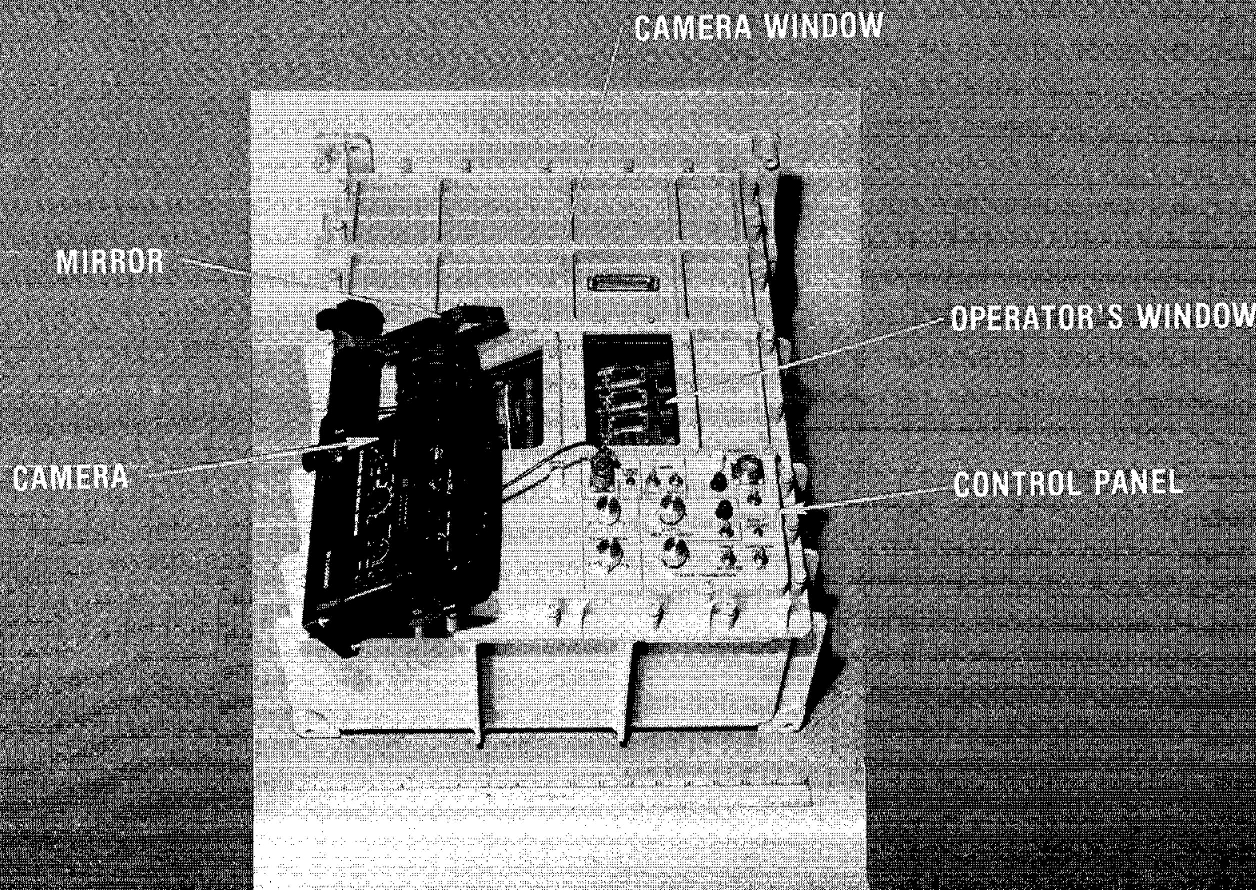
PURPOSES
- BASIC PROCESS/PRODUCT RESEARCH
- GENERAL LIQUID CHEMISTRY
- CRYSTAL GROWTH
- FLUID MECHANICS
- THERMODYNAMICS
- CELL CULTURING



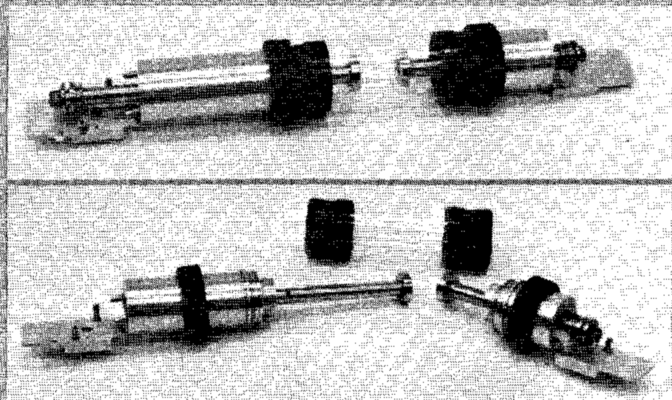
OPERATIONAL CHARACTERISTICS
- HEAT/COOL SAMPLES
- MIX GASSES, LIQUIDS, & SOLIDS
- STIR SAMPLES
- CONTAINED SAMPLES
- FLOAT ZONE SAMPLES
- VACUUM AVAILABLE
- MEASURE TEMPERATURE/VISCOSITY
- PHOTOGRAPH (MOVIE) SAMPLE
- RECORD DATA
- ASTRONAUT OPERATED
- SHUTTLE MID DECK


FEA INTERIOR
HEATER
HEATER TRANSPORT
GAS RESERVOIR
DATA DISPLAY MODULE
SAMPLE CONTAINER

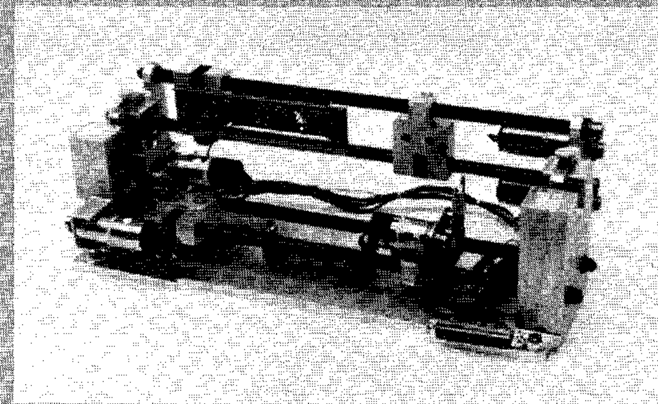
FEA EXTERIOR



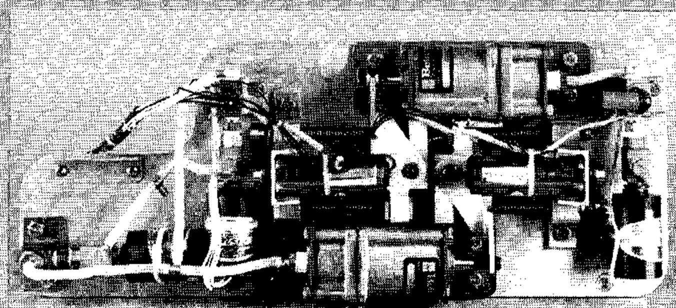
FEA OPTIONAL SUBSYSTEMS



FLUIDS MANIPULATION
EXPERIMENT CONTAINER



EXPERIMENT MANIPULATION
ASSEMBLY



FLUIDS STORAGE &
PUMPING ASSEMBLY

OTHERS

- BULK FLUID CHEMISTRY CHAMBER
- LIVING CELL INCUBATOR
- MULTISAMPLE COLUMN
- CUSTOM HEATER DESIGNS
- SAMPLE CHILL BLOCKS
- SPECIAL INSTRUMENTATION