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Fluid Phase Separation (FPS) Experiment For Flight On A Space Shuttle Get Away Special (GAS) Canister

Final Project Report, June 1990

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Advanced Space Systems Design

Department of Mechanical Engineering

The University of Alabama in Huntsville

FLUID PHASE SEPARATION (FPS) EXPERIMENT
FOR FLIGHT ON A SPACE SHUTTLE
"GET AWAY SPECIAL" (GAS) CANISTER

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Abstract

The separation of fluid phases in microgravity environments is of importance to environmental control and life support systems (ECLSS) and materials processing in space. A successful fluid phase separation experiment will demonstrate a proof of concept for the separation technique and add to the knowledge base of material behavior.

The phase separation experiment will contain a premixed fluid which will be exposed to a microgravity environment. After the phase separation of the compound has occured, small samples of each of the species will be taken for analysis on the Earth. By correlating the time of separation and the temperature history of the fluid, it will be possible to characterize the process.

The phase separation experiment is totally self contained, with three levels of containment on all fluids, and provides all necessary electrical power and control. The controller regulates the temperature of the fluid, and controls data logging and sampling. An astronaut activated switch will initiate the experiment and an unmaskable interupt is provided for shutdown. The experiment has been integrated into space available on a manifested Get Away Special (GAS) experiment, CONCAP 2, part of the Consortium for Materials Complex Autonomous Payload (CAP) Program, scheduled for STS-42.

This document presents the design and the production of a fluid phase separation experiment for rapid implementation at low cost.

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Foreword

"Advanced Space Systems Design" was a new course for the 1989-1990 school year, open to engineering students at the University of Alabama in Huntsville (UAH). The project began in September as the Mechanical Engineering Senior Design Class, ME-465, and continued as a Special Topics Class, ME-496, until June.

The design topic was an experiment for a Get Away Special (GAS) canister which could be used to characterize the effects of microgravity on the fluid phase separation process. Professor Mark Bower put together a proposal which outlined the scope of the project and this was presented to the students in September. In addition, unused payload space on an already manifested GAS canister here at UAH, CONCAP-2, was identified for possible use by the experiment. It was desided that the experiment should be designed with the intent of being integrated into CONCAP-2, which posed severe size and weight constraints upon the designers. Although this went beyond the typical classroom design project, it immersed the students in a true engineering environment where their designs had real constraints and deadlines since the experiment was going to fly onboard the space shuttle.

The Fluid Phase Separation (FPS) Experiment team consisted of seventeen undergraduate students, a graduate reseach assistant, who served as the project manager, and several faculty members who acted as the principal investigators for the experiment. The design was to be carried out by the students as a team effort. The team was required to complete the design of the experiment, make a formal oral presentation of the design for critique by university and NASA personnel, and write this final report. Subsequent work focused upon procurement of materials for fabrication of components and construction of a prototype. Some redesign was conducted at this stage to solve problems discovered with the manufacturing of the prototype.

Due to the small size of the design team, different technical areas and experiment systems were the responsibilities of individual students. It was the responsibility of the project manager to direct the flow of information between the individuals and to integrate the many inputs into a single, coherent design. The principle investigators provide much of the raw information concerning the nature of the fluid experiment, and NASA provided most of the information concerning GAS canister design requirements. It was left to the students to assimilate all of this information and develop a design concept for the experiment, evaluate the different ideas and decide upon the final design which was going to be constructed.

It cannot be stressed enough that this course provided the students with a unique combination of design and manufacturing experience (in a real-life atmosphere) with the rare opportunity to participate in a space-based project.

Acknowledgements

There are many people who provided the Advanced Space Systems Design Project design team with valuable information,to whom we would like to express our sincere gratitude. From the NASA Marshall Space Flight Center in Huntsville, Alabama, we thank Frank Swally, Chris Rupp, Bob Porter, Sherry Walker and Stephen Tucker for their helpful critiques and continued support of the project during the year. We would also like to thank Dr. Lundquist, Jan Bijvoet and all the people associated with CONCAP-2 at the Consortium for Materials Development in Space (CMDS) here at the University of Alabama in Huntsville (UAH). Thanks also to our sponsors from industry who have donated essential materials and expertise to the design team: Mr. Richard Turner of Turner Associates Consultants Inc., Ms. DeAnn Bauer Sievert of Sherwood Medical Co., James Bullington of Intergraph Corp., The Dupont Company-Industrial Films Division, Fluoro-Plastics Inc., Gates Energy Products Inc. A special thanks to the UAH faculty members, Dr. Russell, Dr. Karr and Dr. Smith, who provided invaluable help in the development and evaluation of the systems used in the experiment. And finally, thanks to Steve Noojin for his expert aid in seting-up and operating the SINDA software package.

University of Alabama, Huntsville

RESPONSE TO THE DRAFT REQUEST FOR PROPOSAL

Introduction

The separation of fluid phases in microgravity environments is of importance to environmental control and life support systems (ECLSS) and materials processing in space. A successful fluid phase separation experiment will demonstrate a proof of concept for the separation technique and add to the knowledge base of material behavior. Because of the significance of this experiment it is important that the experiment fly at the earliest possible time. This can be achieved by taking advantage of space available on a manifested Get Away Special (GAS) experiment.

A GAS experiment which is part of the Consortium for Materials Complex Autonomous Payload (CAP) Program has been identified as a potential vehicle for the phase separation project. To ride on the manifested GAS experiment, CONCAP 2, scheduled for STS 40 or STS 42, the phase separation experiment must be integrated into the GAS container and meet the established time schedule for CONCAP 2. The phase separation experiment must be designed such that it will not in any way interfere with CONCAP 2. The phase separation experiment must be totally self contained, with multiple levels of containment on all fluids, and provide all necessary electrical power and control (a barometer switch signal will be available to initialize the experiment). This document presents a preliminary design concept and a development plan for the production of such an experiment. This plan is a fast paced program for rapid implementation at low cost.

Preliminary Design Concept

The phase separation experiment will contain a premixed fluid which will be exposed to a microgravity environment. This exposure in concert with temperature effects will contribute to the phase separation of the compound into component species. When this occurs, small samples of each of the species will be taken for analysis on the Earth. By correlating the time of separation and the temperature history of the fluid, it will be possible to characterize the process. Therefor, the experiment must be capable of storing temperature data with respect to time and two material samples, for each of the phase separation specimens.

The temperature of the fluid will be obtained by a sensor. The temperature record will be stored in non-volatile electrically erasable and programmable memory (EEPROM). The material samples will be obtained by mechanical separation. The samples will remain in the sampling mechanism until such time that they can be analyzed on Earth. This will prevent the samples from being contaminated by the remaining fluid.

For the safety of CONCAP 2, the phase separation experiment must be isolated from the rest of the GAS can experiments. This isolation requires physical containment and electrical isolation. To keep all fluid samples free from contamination and to meet safety requirements, a three tiered physical containment system will be used.

The first level of the containment system will be a spherical vessel which will contain the fluid specimen. The second level of containment will be a container which will house the spherical vessel and all sampling mechanisms. The third level of containment will be the experiment housing. This housing will be the interface between the phase separation experiment and CONCAP 2. To measure the temperature of the fluids and separate the samples, the spherical vessel will have access ports. These ports will be designed to minimize the potential for contamination. The sample separation mechanism will provide one level of containment between the sample and the specimen, and the first level of containment between the sample and CONCAP 2.

The electrical isolation of the phase separation experiment will require a separate control system and power supply. To minimize the complexity and weight of the experiment the control system will be designed such that a computer will not be necessary. The control system will maintain the temperature of the experiment within the specified range and control data logging and sampling. The experiment will be initiated by an input from an externally supplied barometric switch. No other outside control will be required. The temperature range will be determined by the fluids used in the phase separation experiment.

Development Plan

The proposed vehicle for the phase separation experiment is CONCAP 2, a manifested high priority experiment. The development of the phase separation experiment must meet the existing time schedule for CONCAP 2. Development of both experiments will proceed along parallel paths with integration occurring at key milestones as designated by the CAP program and the CONCAP 2 experiment. In the event that the phase separation experiment fails to meet any of the established requirements or key milestones it will be divorced from the CONCAP 2 experiment.

The attached figure shows a proposed time schedule for the phase separation experiment. The preliminary milestones noted are those established for this program and do not necessarily represent milestones established for CONCAP 2. As information on the CONCAP 2 schedule becomes available those milestones will be integrated into the program time line. Key milestones to be noted on the figure are:

2 November 1989 - Design Proposal Due
4 December 1989 - Final Design Due (including all drawings)
- Initiate Procurement
15 January 1990 - Procurement Complete
28 February 1990 - Integration and Assembly Commences
31 March 1990 - Delivery of experiment to NASA for testing
30 June 1990 - Delivery of experiment to Kennedy Space Center
This is an ambitious schedule, nevertheless we are confident that this program can be completed on schedule and under budget providing the best experiment in the shortest possible time at the lowest cost.

1.0 Introduction

The separation of fluid phases in microgravity is of interest for materials processing and long duration life support systems in space. On earth, phase separation occurs due to buoyancy, but this is not the case in the microgravity environment of space. Therefore, materials processing relying on the phase separation of liquid mixtures will not occur in the same way as on earth. This difference could be used to advantage to develop new materials not presently available on earth.

Fluid phase separation has direct application to current research concerning new metal alloys produced in microgravity. To optimize the processing method for the alloys, the relationships between the different phases of the metal must be known (ie. a phase diagram). Microgravity alters the phase diagram. To construct a new phase diagram, the molten metal needs to be analyzed while in space. It has been proposed that a simpler method could use special fluid mixtures to model the molten metals. This has the advantage that the transition temperature of phase separation for most fluids is significantly lower than that of molten metals, so it will be easier to study the fluids in the laboratory and then correlate the data to the metals. The result will be a new space-based phase diagram which can be used to develop stronger, lighter-weight metals.

Another possible application concerns spacecraft thermal control systems. The heat from components, experiments and people must be dissipated from the spacecraft environment. Present technology utilizes pumped liquid thermal transport systems for heat exchange. The heat dissipation is controlled by the mass flow rate of the system which is determined by the size of the pump. Large heat dissipation requires large pumps which utilize a prohibitively large amount of electrical power and add significantly to the weight of the spacecraft. A specialized two phase (liquid to liquid) thermal transport system could be more efficient in accomplishing this task. Therefore, understanding the liquid-liquid phase separation process in space could aid in the design of closed environments, such as the space station and the Mars mission.

A detailed understanding of the separation process is essential to the application of the fluid phase separation technology. Preliminary research concerning potential fluid mixtures and their behavior in space is underway. However, the fluid phase separation process is a complex interaction between temperature and microgravity which is not possible to duplicate in an earthbound laboratory. An experiment is needed which will characterize the separation process in space and demonstrate a proof of concept for the fluid phase separation technique.

At present, there are several approaches available to researchers. The experiment could be placed onboard the Space Lab carried in the shuttle cargo bay. This would allow maximum interaction between the investigator and the experiment, permitting the greatest degree of flexibility. However, the lab does not fly very frequently so the lag time between experiments could be prohibitively long. Also, the experiment must meet the most stringent of NASA safety requirements which would greatly increase the cost of the experiment. Smaller middeck payloads are available which would allow some astronaut interaction while holding down design and fabrication costs. The drawback is the long waiting list at present for the small amount of available space, which could mean that the experiment might take three years to fly. The final alternative involved Get Away Special (GAS) Canisters. The Gas cans can fly in the shuttle bay using excess space and payload not needed by the primary mission experiments. They are self-contained units which permit a great deal of design flexibility. Furthermore, they are the least expensive and can be flown quite often. Due to the need for multiple experiments with many fluid pairs and the desire to fly the experiment as soon as possible, it was decided that a GAS canister was the optimal means of getting the experiment into space. Here at the University of Alabama in Huntsville, a project was undertaken to design a fluid phase separation experiment which would fulfill the requirements of the researchers and be capable of integration into a GAS canister.

The experiment will record a complete temperature history of the fluids along with samples of component species to be analyzed on Earth. The phase separation experiment is totally self contained, with multiple containment levels for all fluids, and provides all necessary electrical power and control. Since the GAS canister is quite large, it was decided to use a modular design such that the experiment could be increased or decreased in size depending upon the desires of the researchers and the available space. Simultaneously, it was discovered that there was space available on a manifested GAS canister, CONCAP 2, which was scheduled for STS-42 in December of 1990. The Gas can is part of the Complex Autonomous Payload (CAP) Program and contains a primary experiment which cannot be interfered with in any way. The project proceeded with the design using constraints given by CONCAP-2 in addition to those from the fluids researchers.

This document presents a design for the Fluid Phase Separation (FPS) Experiment. It includes the description of the process, design of systems and outline of a construction program.

2.0 Experimental Process

The liquid-liquid phase separation process is shown schematically in Figure 1. The system is initially a mixture of two fluids at temperature T_i

within a container. As the system is cooled, it will reach a transition temperature, T_s, at which point the two component fluids will begin to separate. Further cooling results in three separate components: the original mixture and the two constituents. Eventually, the two constintuents will completely separate from the mixture.

On earth, differences in density typically drive the separation process. In microgravity, minimal surface energy will be controlling the separation. It is anticipated that this will produce two spherically shaped volumes containing the different component species. One component will be collected at the center of the fluid container, while the other will be wrapped around the first, positioned at the edge of the container. The fluid phase separation experiment will be used to characterize this process.

A mixture of Succinonitrile and Cyclohexane is of particular interest. Succinonitrile is a solid at 20° C, room temperature, and has a vaporization temperature of 85° C. This material is highly reactive with most metals except for gold and stainless steel. Plastics and rubber are also reactive but teflon is not. Cyclohexane is a liquid at room temperature and has a vaporization temperature above 120° C. It is an organic solvent which will dissolve most adhesives. All of the materials used to contain and support the fluids must be carefully selected so as not to interact with the liquids to produce erroneous results or jepordize the saftey of the experiment.

The active operation of the experiment is linked to temperature control of the fluid. The mixture will not need to be heated prior to the experiment start-up since the mixture will contract uniformly upon freezing. This is the "dormant" phase shown in Figure 2. Just prior to the second sleep period, during a time of low activity, each of the fluid samples will be heated to a predetermined temperature and allowed to stabilized. The fluid mixture will begin to cool until the "transition" temperature is reached. The phase separation will then begin, accompanied by a release of heat. This will cause the fluid temperature to temporarily stabilize. As phase separation continues, the fluid temperature will once again begin to fall and the sampling mechanism will be activated. The temperature of the fluid will be stabilized and maintained constant, permitting small samples of each of the species to be taken for analysis on earth. By correlating the time of separation and the temperature history of the fluid, it will be possible to characterize the process. After the sampling is complete, the experiment will be deactivated for the duration of the space shuttle mission.

3.0 Design Summary

The fluid phase separation experiment has a total weight of 11.8 and a volume of 1105 in^3 which is within the initial payload constraints imposed by CONCAP 2. This value includes six fluid containers and the support apparatus, the controller and power supply. The overall dimensions are: 14.5 in (width) x 8.5 in (height) x 9.75 in (depth from the mounting plate). Figure 8a is a mass schedule for the experiment, and Figure 8b is a complete materials list. Volume of an individual fluid sample is 0.22 in^3. The GAS canister is shown in Figure 4a with the relative placement of the components within the GAS Can shown in Figure 4b.

3.1 Structural System

The structure will support the experiment and isolate the fluid phase separation experiment from the rest of the GAS Can. The whole experiment will be contained within this shell and will allow the liquid containers and sampling mechanism to be attached to the GAS Can mounting plate.

Several ideas for the shape of the outer shell were considered. The criteria used to evaluate the proposed shape included: size of the enclosed volume, minimization of the weight, ease of fabrication and structural stability. The dimensions of the GAS cannister and the allocated space provided by CONCAP-2 set the maximum dimensions. The experiment was to be located in the bottom, on one side of the cannister and have a height of no more than 10 in. Later, the height was further reduced to 8.5 in. due to a change in the primary experiment, CONCAP-2.

It was decided that the volume occupied by the fluid phase experiment should be large enough to fully contain six fluid sample containers, a controller and a battery. Since the experiment had to be completely isolated from the other experiments in the GAS cannister, there needed to be a minimum of seams and joints in the outer shell. To maximize structural stability, the shell needed to be self supporting.

The semi-cylinder was chosen as the best shape for the outer shell (Figure 5). The shell will have overall dimensions of 14.5 in. in length, 8.5 in. in height and a depth (measured out from the mounting plate) of 9.25 in. The shell will be formed from 0.031 in., type 304 stainless steel sheet which is inert to the chemicals used for the fluids. By using thin steel, we can maintain the high strength and minimize the weight. The 304 stainless steel is easy to form and can be welded to increase the strength of the shell and provide containment.

To reduce the weight, there is no backplane on the shell. The containment is maintained by covering the GAS Can mounting plate with a continuous 3 mil thick teflon sheet. A 0.125 in thick teflon O-ring gasket is placed between the outer shell and the mounting plate to absorb the displacements induced by thermal and mechanical loads. This will maintain a tight seal and prevent contamination of the other experiments in the GAS Can.

The shell is held to the mounting plate by 22, #10-24 grade 8 socket head bolts with 0.5 in. washers. The bolt material is A-286 corrosion resistant steel with an allowable stress of 20 Ksi. The bolts are spaced at 2 in. centers around the 0.75 in. flange on the outer shell. Although twenty-two bolts are not needed to support the outer shell, they are needed to maintain an adequate distributed pressure between the teflon gasket and the mounting plate to ensure a tight seal under launch loads. This bolt configuration produces a worst case maximum bolt stress of 3000 psi., for a factor of saftey of 6, under a 10 g load applied during the launch. The outer shell experiences a maximum stress of 400 psi. at launch, which is well below the yield stress of the stainless steel which should prevent even a fatigue failure of the outer shell(Figure 6a and 6b).

The shell will be penetrated at three points. A D-type electrical connector is located on the bottom of the shell to connect with control cables from the shuttle (located at the bottom of the GAS can). The connector will have gold plated pins and a teflon gasket on the interior to prevent corrosion and contamination of the GAS Can. The other two openings are covered with seven-micron teflon filters in a 304 stainless steel housing. The filters are 25 mm. diameter and have a maximum pressure of 100 psi. at the inlet, with an allowable pressure difference of 50 psi. This will permit the purging of the fluid phase separation experiment with nitrogen prior to launch. Also, these two ports will permit rapid dissipation of the interior pressure while maintaining containment of the fluid in the event that the GAS Can is depressurized while in space. If this were to occur, the fluid would sublime to a solid and be trapped by the filter while the nitrogen gas could escape, preventing a rupture of the outer shell.

An analysis of displacements showed that deflections of the large diaphram-like surfaces were acceptable, but a dynamic analysis showed that the fundamental frequency of vibration was too low. To improve the dynamic response of the outer shell, triangular ribs were added to the top, bottom and side of the shell. These ribs broke up the area which could freely oscillate, and stiffened the surfaces to out-of-plane motion.

3.2 Fluid Sampling and Specimen Retrieval System

Within the outer shell is the fluid phase separation experiment. The experimental apparatus is composed of three subsystems: the fluid containers, the sampling mechanism and the structural frame (inner shell). Size and weight restrictions determined the maximum number of fluid sampling systems to be six.

Many materials were considered for the fluid containers. Due to the unusually corrosive nature of the fluids, stainless steel, gold and teflon were the only materials which were chemically suitable. A material with a low specific gravity was desired to minimize weight. Furthermore, uniform thermal conductivity was necessary to transfer heat from the external heaters into the fluid. Since the external heaters are to be positioned on the outside of the container, it is essential that the material have a high melting point. Finally, a high tensile strength will be needed to withstand the expected loads during the shuttle flight. All of these criteria are met by teflon.

The teflon was machined into the desired geometrical shape. A 0.75 in. diameter spherical fluid cavity is inside a truncated cone with a nominal wall thickness of 0.25 in. A flat octahedron plate passes through the sphere/cone dividing it in two halves. Assembly of the fluid containers is accomplished using a ferrel type joint for alignment with six bolts to ensure an adequate seal. This will also provide the first level of containment for the fluid. The orientation of the fluid containers is shown in Figure 7.

Although a spherical shape both inside and out would be optimal for heat flow considerations, the exterior sphere is difficult to produce. Therefore, a cone was used since it can be easily machine and still provides a minimum of exposed surface to conduct and radiate heat away from the fluid. The shape will produce an even heat flow through the teflon container and into the fluid sphere.

Provisions had to be made to fill the spherical cavity of each sample container after assembly. This problem was remedied by designing a special fill port that included a stainless steel tube press fit into the fluid container and sealed at the outside with a removable teflon plug. This permits over filling of the spherical cavity so that no air pockets are present within the sphere.

The teflon container has a maximum tensile strength of 3000 psi. which is strong enough to withstand the increase in internal pressure created by partial vaporization of the fluid within the cavity (an internal pressure of 100 psi.). However, the controller should terminate the heating of the fluid before this pressure is reached.

Surrounding the fluid containers is the inner stainless steel shell which provides the structural support and acts as the second level of containment. The housing will be fabricated from the same material as the outer shell discussed earlier and will also have welded seams. The fluid containers will be mounted within this housing but separated from the stainless steel shell by an insulating phenolic pad to minimize heat transfer away from the fluid spheres. Each of the fluid containers is attached to the inner shell by four, #5-40, socket head screws, threaded 0.375 in. into the teflon. Under the worse loading case at the time of launch, the maximum load (including the preload) is 84 lbs. per screw. This gives a safety factor of 9 with respect to tear out, bearing and shear stresses.

The inner shell is constructed in two parts (Figure 8). A base plate mounts the shell to the GAS cannister with 12, #10-24, grade 8, socket head screws. The A-286 corrosion resistant steel used in the screws has a 20 Ksi. allowable tensile stress which is four times greater than the maximum stress of 5000 psi. which occurs at launch. The base plate has four flanges which are normal to the surface of the plate for attachment of the box containing the fluid spheres.

The box has four sides (open front and back), and is made slightly larger than the tabs of the base plate. The box is then bolted to the tabs on the base plate. Stainless steel nuts were spot welded to the base plate to accept the 12, #5-40, A-286 steel, socket head screws. This was done to permit easier assembly of the experiment by allowing access to the front and back of the fluid spheres. To seal the box onto the base plate, a teflon O-ring gasket fits inside of the tabs. To completely seal the box, the front panel is attached using 12, #5-40, A-286 steel, socket head screws and a teflon O-ring gasket. As before, stainless steel nuts are welded onto the inside edge of the box to accept the screws. This panel permits access to the spheres to fill them prior to launch.

The whole structure of the inner box has a maximum stress of 900 psi. which is well below the yield stress of the stainless steel which should prevent failure of the inner shell. To stiffen the inner shell and to provide a rigid plate upon which to mount the rotary actuators, a stainless steel plate is welded across the interior of the box. Once all of the components are in place, selected areas inside the box are filled with expanded polystyrene foam which helps to dampen vibration and provides thermal insulation.

The sampling mechanism is composed of two tubes fitted one inside the other (Figure 9). The exterior tube is rigidly mounted across the inside of the fluid sphere. It has two holes in the wall of the tube positioned such that one is at the center, and the other is near the edge. A rotary actuator will rotate the inner tube to align the inner two holes with the outer two and permit diffusion of the fluid species into the inner tube. After sampling is completed, the inner tube will be rotated in a reverse direction to seal the samples within the innermost tube.

The exterior tube is limited to approximately 0.050 in. in diameter in order to limit the effects of wetting along the tube which would destroy the concentric sphericity of the two fluids as they separate. To prevent this, the tube has two small disks or fins on it to keep the one fluid from wetting along the whole length of the tube. This will ensure that each component species is sampled.

In order to provide rigidity, maintain precision and to simplify the design and construction, the sampling tubes are made from stainless steel spinal needles, which are modified as needed. The ends of the needles are closed by a quick touch with a TIG welder. The rotary actuators have a maximum 40° rotation which limits the size of the holes in the tubes to 0.013 in. in diameter. To make sure that the holes on both tubes are aligned and free of jagged edges, which would disrupt the fluid flow into the tube, both holes are simultaneously cut with a file and then the tubes are dipped in nitric acid to remove burrs.

An interference or press fit is used where ever a teflon to stainless steel seal occurs. The outer tube pierces the sampling chamber, the rotaty seal between the inner and outer tubes, and the plug in the inner tube are all examples of an interference fit. Adequate pressure is maintained at the seal up to 130° C. This allows for the difference in the thermal expansions of the two materials.

3.3 Environmental Control System

The fluid phase separation requires careful control of the fluid temperature during the experiment. Conductive and radiative heat flow will account for the heat transfer within the GAS Can. The design of the environmental control system must compensate for the rapidly changing temperatures of the GAS Can environment while providing enough heat to raise the fluid temperature above the transition temperature so that phase separation can occur.

The problem is not one of steady state conduction but of time varying conduction. The orbit (sunlight to darkness every 45 minutes), periodic turning within orbit, and the attitude of shuttle within orbit (earth or space viewing) will influence the ambient GAS Can environment. The environment may vary from -100° to 20° C. Therefore, the design of the heaters and the insulation must consider the rate at which heat will be lost from the fluid so that the cooling time is long enough. Likewise, the cooling period must not be too long or the experiment may not be completed within the allotted time.

Initial calculations modeled a fluid heated to 90° C and cooled to 20° C which is surrounded by a cold environment. The fluid is a sphere, at a uniform temperature, which is suddenly immersed in a colder fluid. Surrounding the fluid is a low density, high heat capacity polystyrene insulative layer. As the thickness of the insulation layer increases, the cooling time increases. However, if the ambient environment is too warm, the cooling time becomes prohibitively long. This means that the insulation layer must be designed for the warmer environment and supplemental heating used to stretch the cooling time in colder environments.

More detailed modeling was done using SINDA (Systems Improved Numerical

Differencing Analyzer). This computer program is well suited to solving lumped parameter representations of physical problems. The model represents the heat flow paths as a conductor/capacitor network.

The experiment components were first broken into smaller elements and assigned a nodal number. The volume and capacitance of each node was calculated. The nodes are then linked to reflect conductive and radiation heat flow paths between all of the possible nodes. The final aspect is to assign boundary nodes to represent the properties of space around the GAS cannister. This computer model is then converted into executable Fortran code, and run for a predetermined amount of time or until steady state is reached. The end result is a complete temperature history of each node as it cools and/or warms. The temperatures of the fluid were of interest in the cooling phase, and they were dependent upon the temperature chosen for the heat sink (space node). From these tests, the heaters and the layer of insulation were sized and are shown in Figure 10.

A polystyrene layer, with nominal thickness of 1 in, will be affixed to the exterior of the fluid container housing. Additional insulation can be added within the cylindrical aluminum container and inside the fluid container housing to shield individual fluid containers from the other containers. This will allow customization of individual fluid samples without affecting the overall performance of the experiment.

Sensors will constantly monitor the temperature of the fluid and activate the heaters to keep the liquid from freezing. In orbit, the expected equilibrium GAS Can temperatures are -100° C during space viewing and -10° C during Earth viewing. Due to occassional rotating of the shuttle, the sun may heat the outside of the GAS Can which may cause the temperature within the GAS Can to rise to 20° C. Although the effects of the extreme cold can be minimized with heaters and insulation, the warming of the GAS Can will be a problem. There is no adequate means at our disposal to cool the experiment if it should get too warm. Because of this, the thermal heating design was determined for the worst case temperatures of -100° C and it is assumed that the insulation provided will prevent the experiment from warming too much.

Once the experiment begins, the fluid will be heated to a maximum temperature of 90° C over a one hour period and then maintained at that temperature for five hours. This will require 81 mW/hr or 486 mW total. The fluid will also need to be cooled slowly, so intermittent heating may be required during cooling. Once sampling of the two fluid components begins, the fluid temperature will be stabilized for an additional hour. This heating load is used to determine the size and number of heaters required.

The heat flow for a single fluid container is 81 mW/hr over a six hour period. Because there is some thermal lag in transferring the load, and the heaters should not be in continuous operation, the heaters had to have a greater output than the heating load required. It was determined that the heaters should operate only one-third of the time which requires 243 mW/hr. With six heaters chosen, the output from a single heater must be 40.5 mW/hr. Given that the voltage available from the battery is 6 volts, the resistance of an individual heater was calculated to be 0.88 ohms. These requirements can be met by Thermofoil heaters, each being 0.5 inches in diameter, with an effective area of 0.15 square inches.

For control and safety, each heater will have a resistance thermometer laminated within it. The resistance thermometers (RTD's) increase resistance with temperature, and are considered to be accurate and stable sensing devices. The RTD chosen will have either platinum, nickel, copper, or nickel-iron elements.

Temperature sensors will also be needed to monitor the temperature of the sample, as well as the temperature of the battery. They must have an output range from 0-10V. For the sphere, it will be necessary to have a coated sensor which will resist any type of reaction with the fluid. It must have a temperature range at least from -50° to 150° C. A teflon coated thermocouple with a length of 0.05 in and a time constant of 1 sec has been selected.

3.4 Controller

The controller executes three primary functions. Function one provides dynamic temperature contol of six fluid samples during the experiment cycle. In addition, the temperature of the experiment battery pack will be regulated to maintain optimum battery output throughout the experiment cycle. Function two is the independent timing and control of each of the sample actuators once the phase transition is reached. Function three is the data logging in non-volatile memory of experiment temperatures for the duration of the experiment's operation. Finally, the controller will monitor saftey and control power for the experiment. The control and data logging requirements for the Fluid Phase Separation Experiment are relatively simple. The requirements fall into four catagories. These catagories constitute the logical division of work for the controller (Figure 11).

Category one is data storage. The non-volatile electrically erasable and programmable memory (EEPROM) requirements are driven by the number of temperatures stored multiplied by the sample rate, multiplied by the experiment total operating time. A three day experiment cycle time will generate 30240 bytes which need to be stored.

Category two is active temperature control. The active control for temperature requires thirteen separate temperature inputs, two each from each of the six fluid specimens plus one from the battery. In addition there are seven temperature control outputs, one for each of the six experiments plus one output for the battery.

Category three is the control of the experiment actuators. There are six one bit control outputs for the actuation of the experiment sample mechanisms. The timing for the sample mechanisms will be controlled by the temperature inputs from the experiments themselves. A minimum time delay between sample actuation will be used to prevent overloading of the batteries.

Category four covers the general control requirements. This includes the input from the GCD switch actuated by an astronaut to begin and end the experiment (Figure 12). If there is an indication that the battery charge is low (voltage is less than 4.75 V for an extended period), a non-maskable interrupt will be sent to the controller to shut itself off. This is done for safety since this is the minimum reliable operating voltage for TTL digital logic. Also, a software timer will be monitored by the processor to indicate that the controller is operating the experiment properly. If the experiment does not seem to be progressing (the fluid is not cooling, etc.), a maskable interrupt will be sent to shut off that portion of the experiment. Furthermore, if any of the heaters should fail in the "on" position, an interrupt will cause the controller to sink enough current to blow a fuse and thereby disable the bad heater.

To permit speed in construction and ensure certification for flight, the controller will be a modification of NSC 800 controller from the GAS Explorer Program. To test the logical sections and permit integration of the experiment and controller, simulated mission tests will be performed at The University of Alabama in Huntsville.

3.5 Power Supply

A power supply is needed to provide power to various systems in the experiment: sample actuators, fluid heaters, battery heater, data acquisition and storage, and the experiment controller. Collectively, these systems require 3.2 amphours for a sixty hour experiment duration. A 6 volt, 5 amphour Gates Lead-acid Monobloc Battery, 5.47 in. in length, 2.11 in. in width, and 3.02 in. in height will provide the necessary electrical power. The battery weighs 2.43 lbs, is self-contained in a flame retardant material and is flight qualified. The battery is fused so that if a catastrophic short circuit were to occur, the fuse will open to isolate the battery and stop the experiment.

4.0 Safety

Safety has been of primary concern throughout the design process for the experiment. The potential hazards concerning possible collision, corrosion, explosion, and fire were identified. Each was carefully examined and a detailed description of the hazard, hazard causes and hazard controls are presented. All of the safety requirements are referenced from NSTS 1700.7B, "Safety Policy and Requirements for Payloads Using the Space Transportation System." Appendix B contains the safety documents for this experiment.

Collision is of paramount concern for any experiment on board the space shuttle. Because of structural failure, damage could occur to surrounding experiments or to the shuttle itself. The result could be a loss of control or even the ability of the shuttle to stay in orbit. The ultimate hazard would be penetration of the crew compartment, placing the safety of the astronauts in jeopardy. To prevent these hazards from occuring, a factor of safety of 1.4 was applied to all structural design. Furthermore, close inspection of all assemblies for quality of materials and workmanship will reduce the potential for material failure. The applicable NASA safety requirements concerning collision (206, 208.1, 208.2 and 208.3) have been met.

Damage of the fluid containment vessels caused by sudden expansion of the sample fluid, collision, or a fire could result in the release of some corrosive material. If the fluid comes in contact with metal, the reaction may weaken the metal and cause the component to fail. To prevent this hazard, the experiment is self contained with three levels of containment surrounding the experimental fluid. This containment will protect the surrounding experiments by minimizing the spread of shrapnel and corrosive material if a structural failure occurs. These measures fulfill the safety regulations concerning corrosion (206 and 209.1).

Overheating of the battery due to heater runaway, polarity reversal or short circuit could cause the battery to explode. The battery explosion could spread corrosive material and shrapnel throughout the GAS Can. This is prevented by using a sealed, flight qualified battery along with a fused bus to prevent short circuits. Finally, a pure nitrogen environment around the experiment will deprive a fire of the oxygen necessary to burn. Non-flammable elements will be used near connections and all wiring and heaters will be properly inspected. The design is in line with the NASA safety regulations for explosion and fire (206, 213.1 and 213.2).

5.0 Project Management

The design has emphasized the use of prefabricated components whenever possible to quicken the procurement and assembly of the experiment. The delivery of the battery will be set for August so that the battery is not over six months old at the time of launch. The acquisition of the controller is paramount to assembly of the experiment. Adequate time is needed to modify and test the controller.

The project was designed and assembled by engineering students at the University of Alabama in Huntsville. The fall 1989 Senior Student Design class (ME 465) was the nucleus of the design team. The students were responsible for generating all of the necessary design documentation. They will also serve as the transition to the construction phase of the experiment. Construction has begun, with anticipated completion by August of 1990. The current work is done by students enrolled in a "Special Topics Class: Advanced Space Systems Design". The resumes of the design team are included in Appendix C.

The planned schedule for the construction of the fluid phase separation experiment is a fast paced program to permit complete integration of the experiment into CONCAP 2. The development of the phase separation experiment must meet the existing time schedule for CONCAP 2. In the event that the phase separation experiment fails to meet any of the established requirements, it will be divorced from the CONCAP 2 project.

Figure 13 shows the revised time schedule for the phase separation experiment. It should be noted that originally, it was unknown wether CONCAP-2 was to fly on STS-40 in August, 1990 or STS-42 in December, 1990 since these were the only two flights with the GAS Bridge installed. However, due to the schedule of CONCAP-2, they were finally approved for STS-42. Since then, the shuttle schedule has been further delaided due to problems with one of the shuttles which has indefinetly postponed the flight. The current most likely date for launch of STS-42 is April of 1991. We are confident that the fluid phase separation experiment will meet this deadline.

6.0 Conclusion

The fluid phase separation experiment will characterize the liquid-liquid phase separation process in a microgravity environment. The experiment capitalizes on a cost effective system (GAS canister) while maintaining a high degree of experiment flexibility. The design will allow six samples of a fluid to be monitored for three days while in orbit. The system will record temperature data and obtain samples of the component species for analysis on Earth. The data will be analyzed to produce a phase relationship or phase diagram for the fluid mixture. Ultimately, the FPS experiment will increase the knowledge base of material processing and provide information for the design of long duration life support systems.

Figures

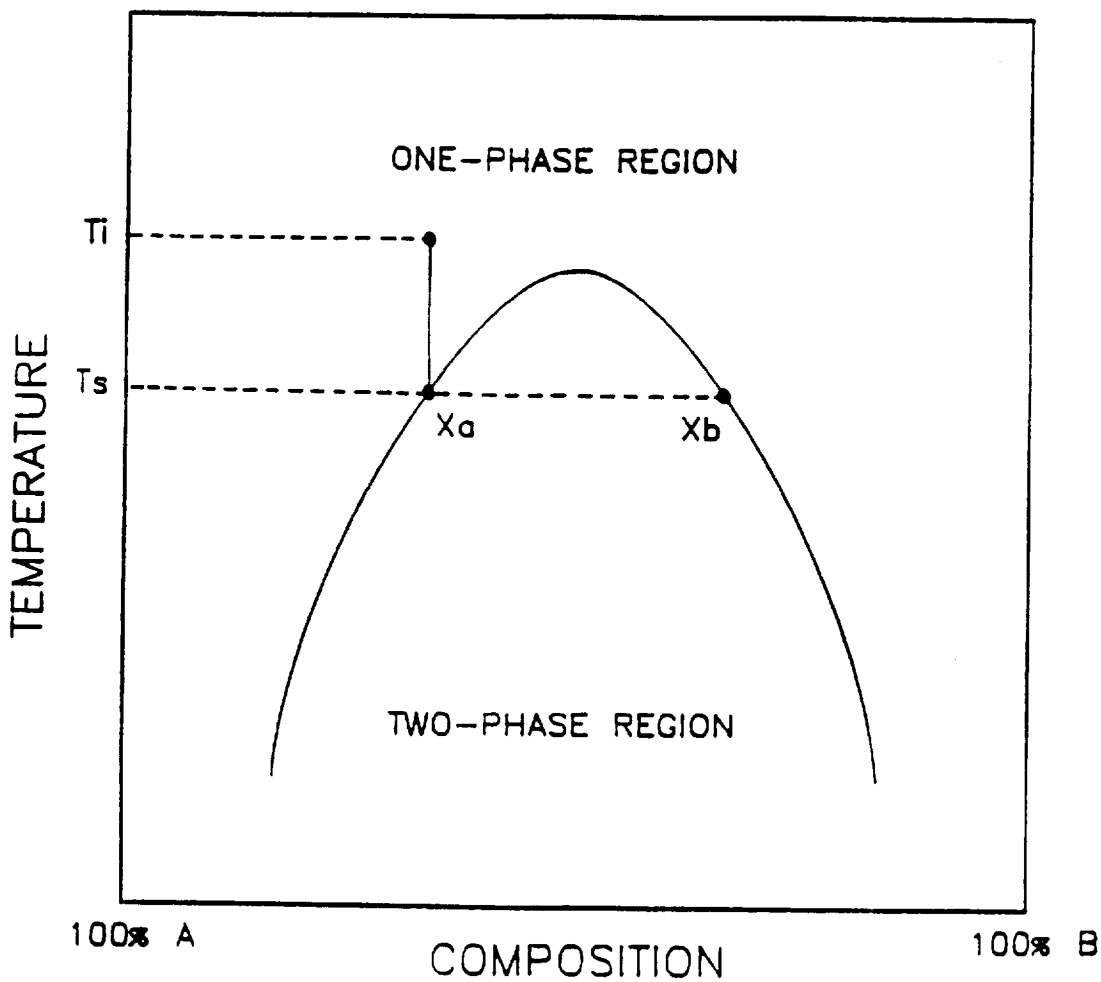


Figure 1 - Phase Separation Process

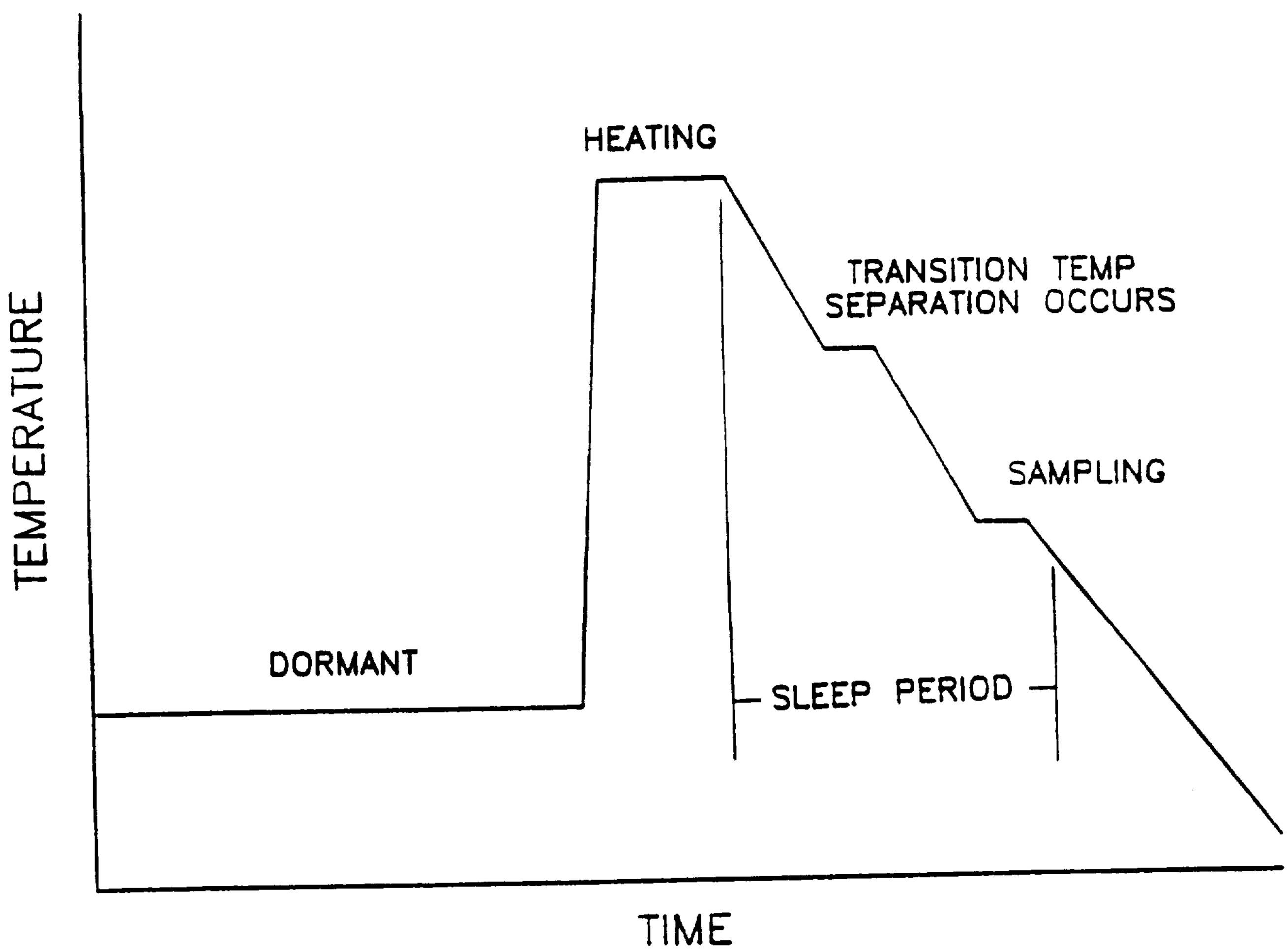


Figure 2 - Experimental Process, Time History For A Single Fluid Sample

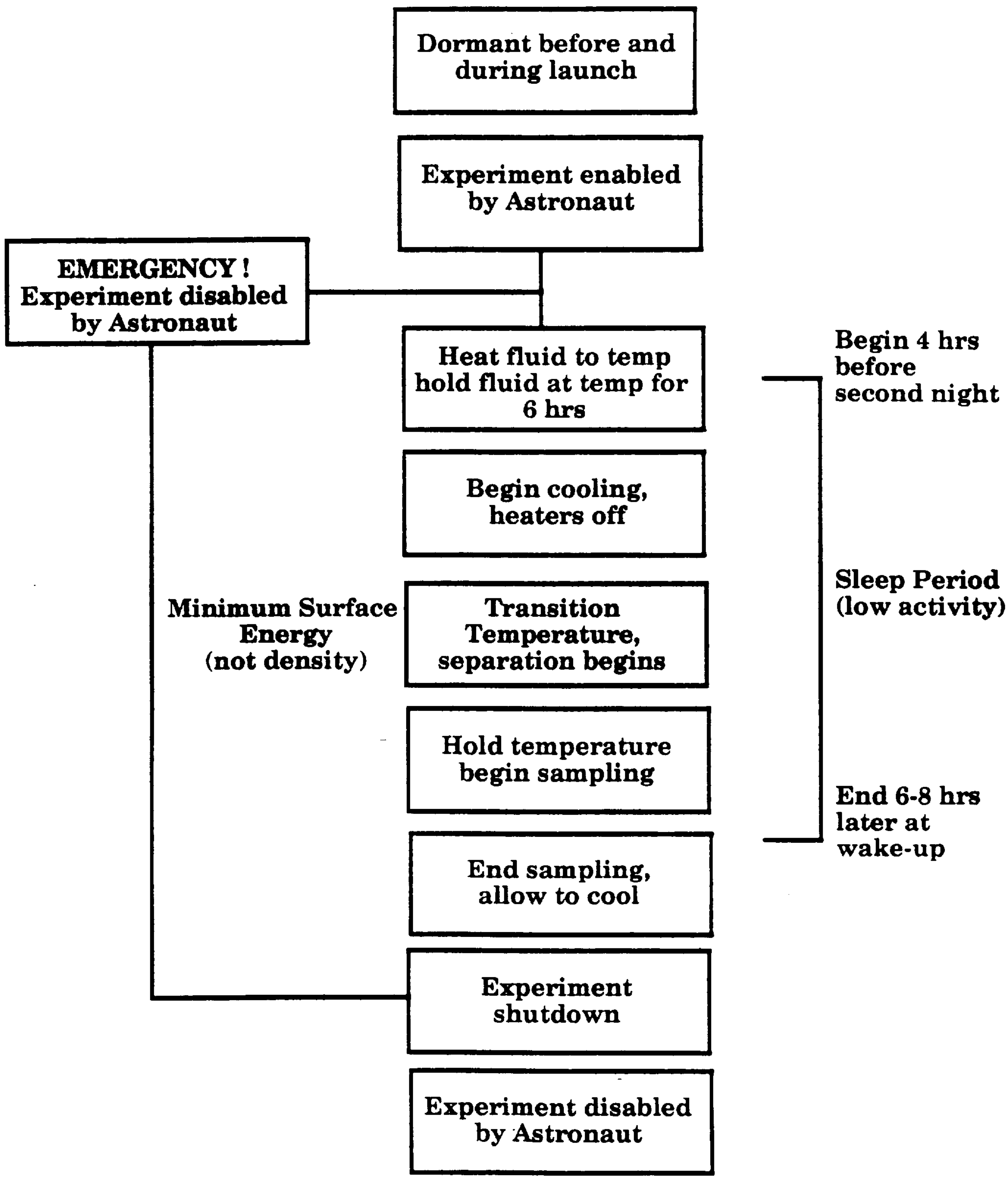


Figure 3 - Experimental Process, Block Diagram

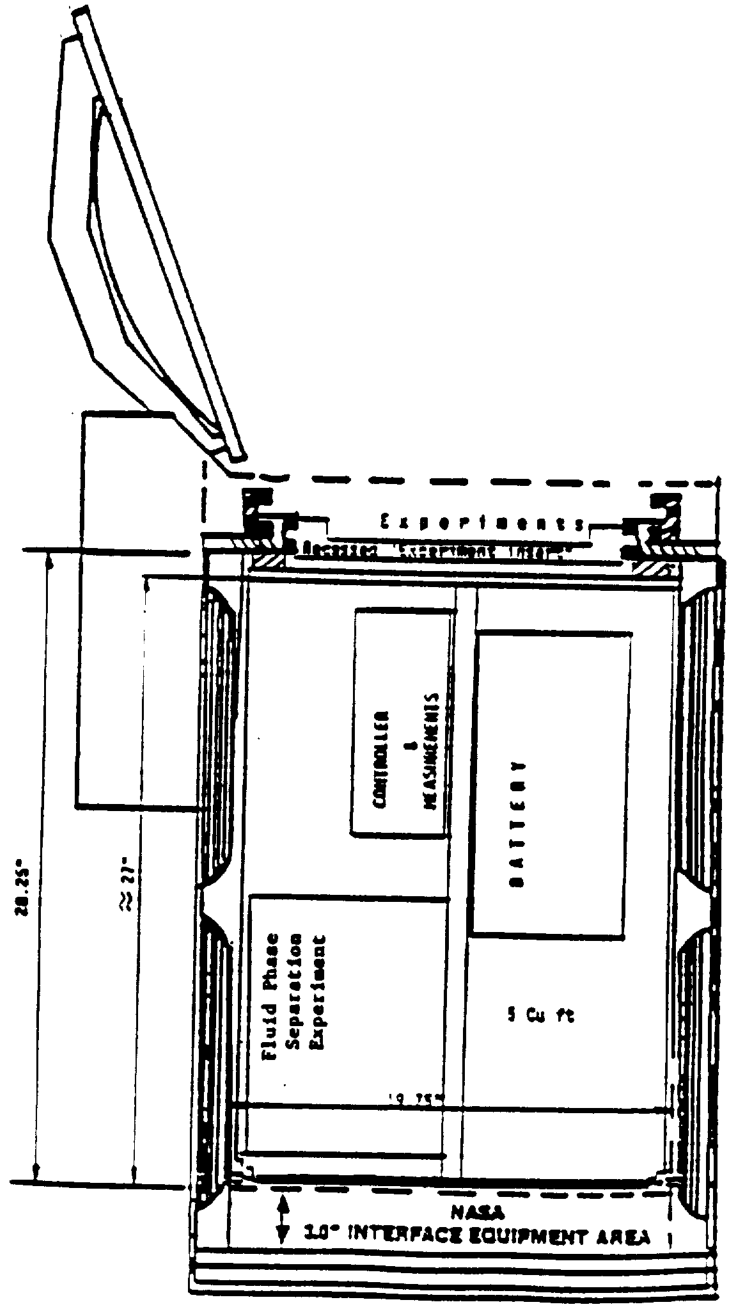
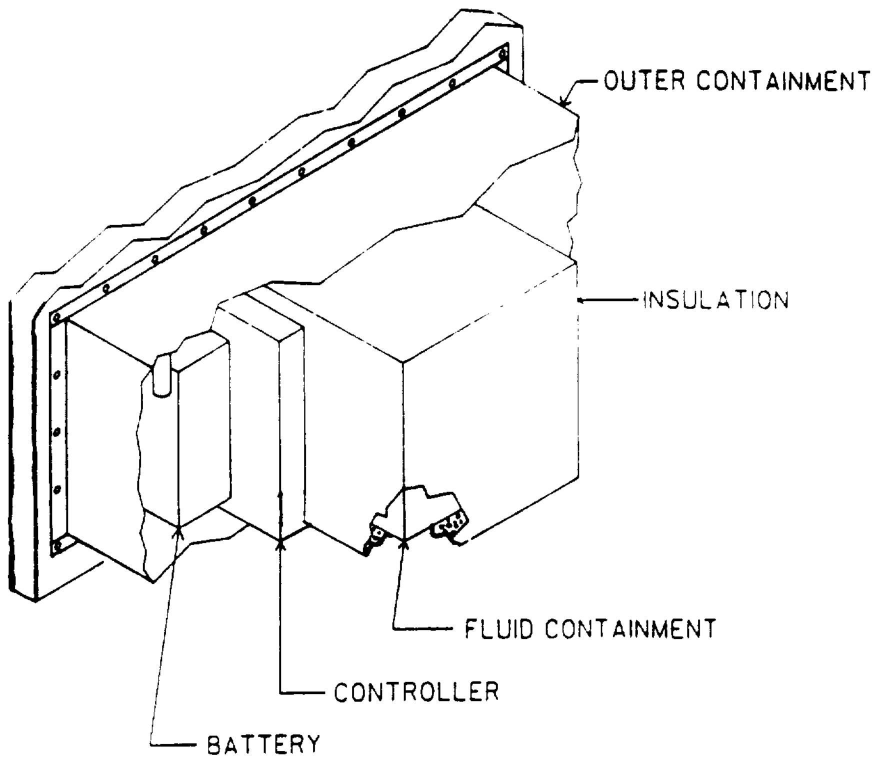


Figure 4a - Verticle Section Of CONCAP-2 GAS Canister
(showing placement of FPS Experiment)



OUTER CONTAINMENT IS CUT AWAY TO EXPOSE INTERNAL COMPONENTS.

Figure 4b - Isometric View Of FPS Experiment Systems

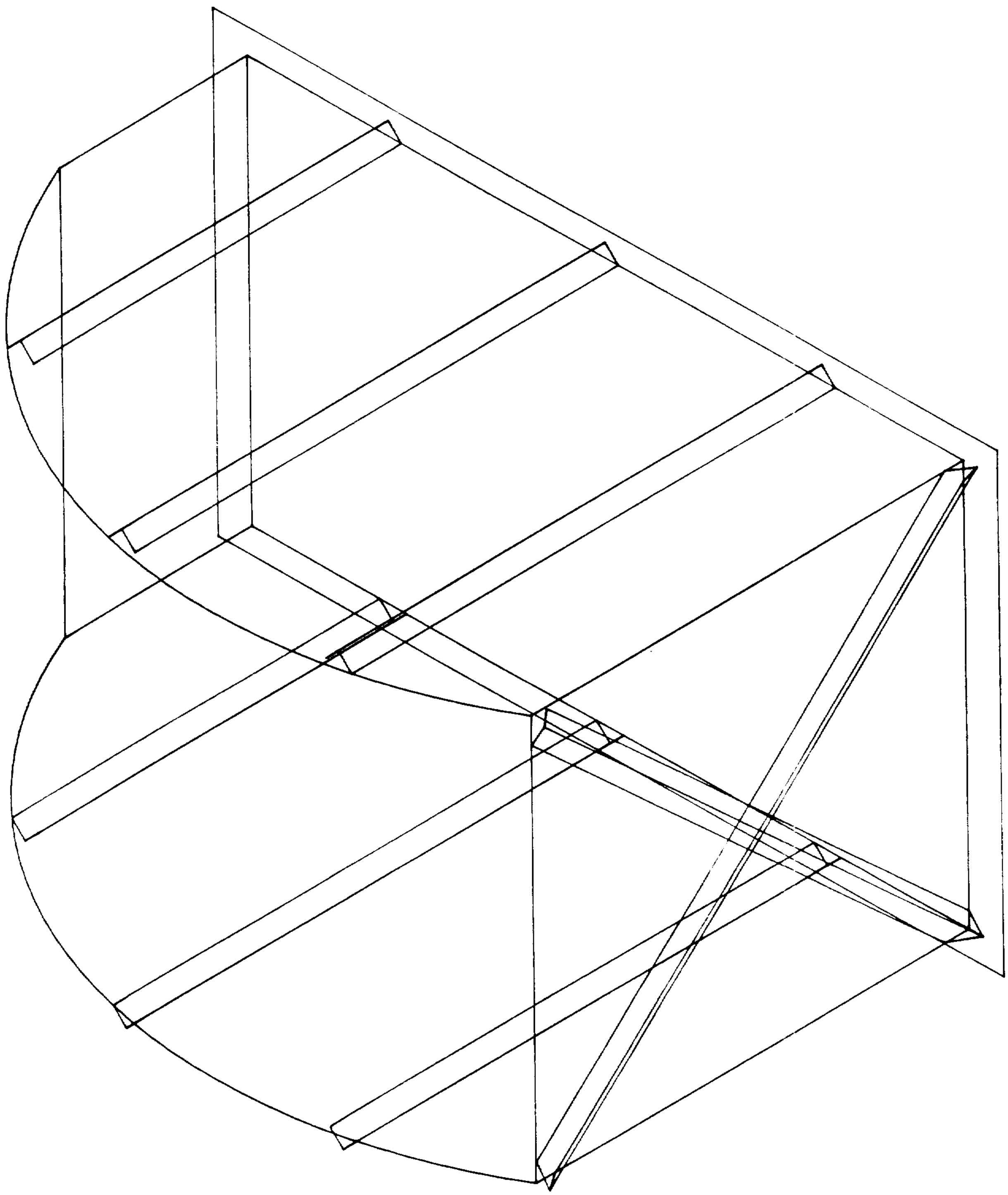


Figure 5 - Outer Shell Containment and Structural System

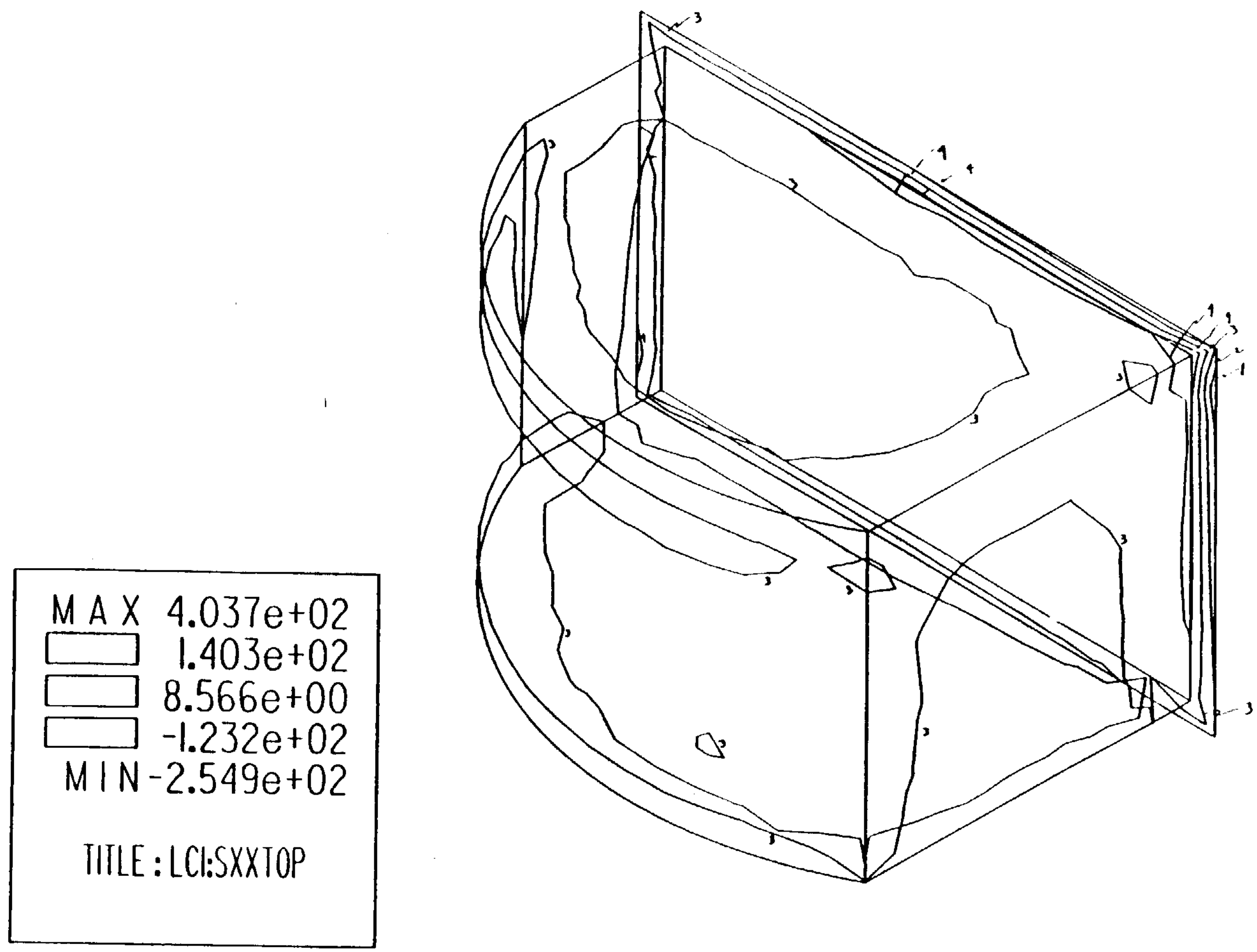


Figure 6a - Outer Shell Stress Field
(stress component in the plane of the shell)

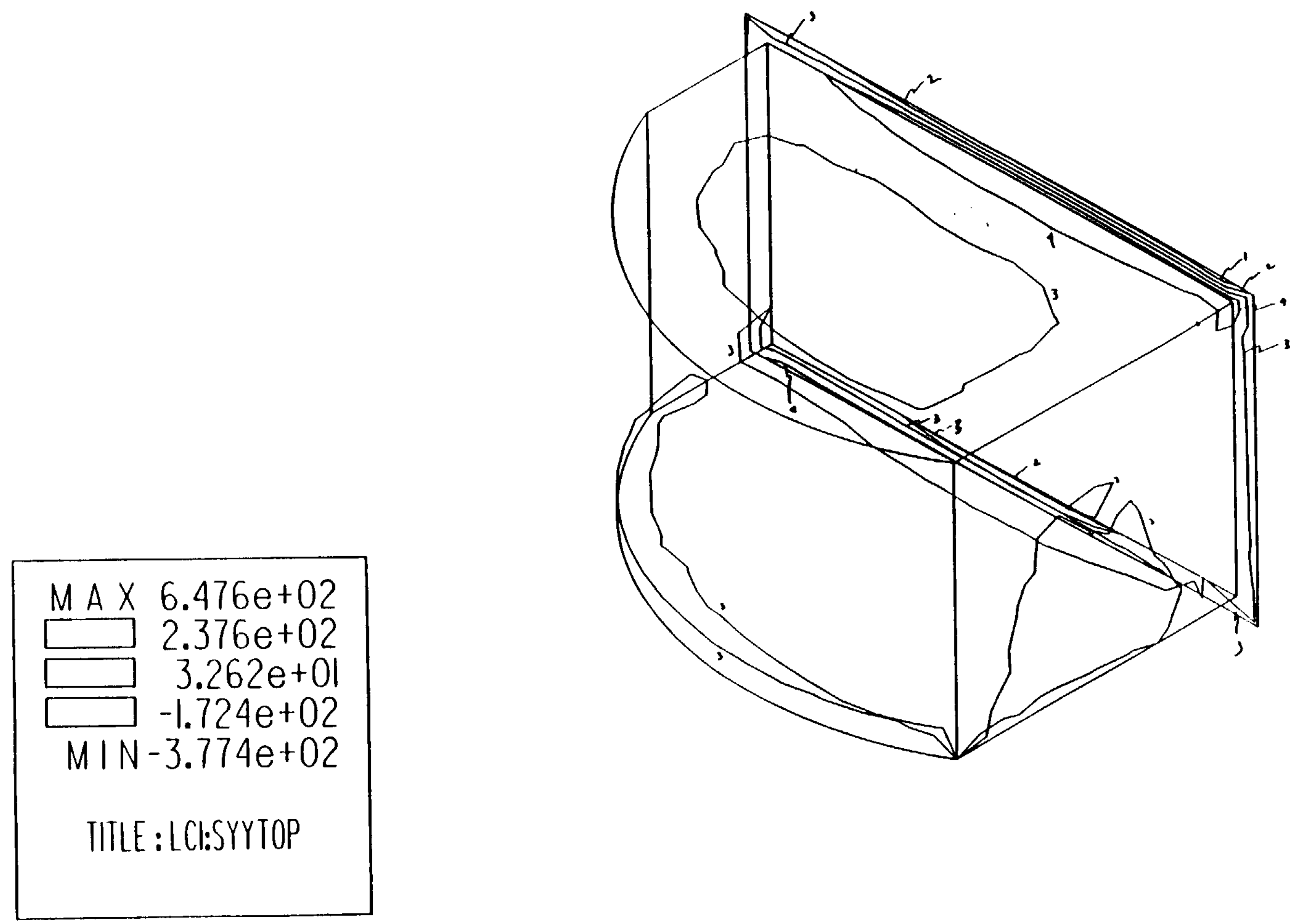


Figure 6b - Outer Shell Stress Field
(stress component in the plane of the shell)

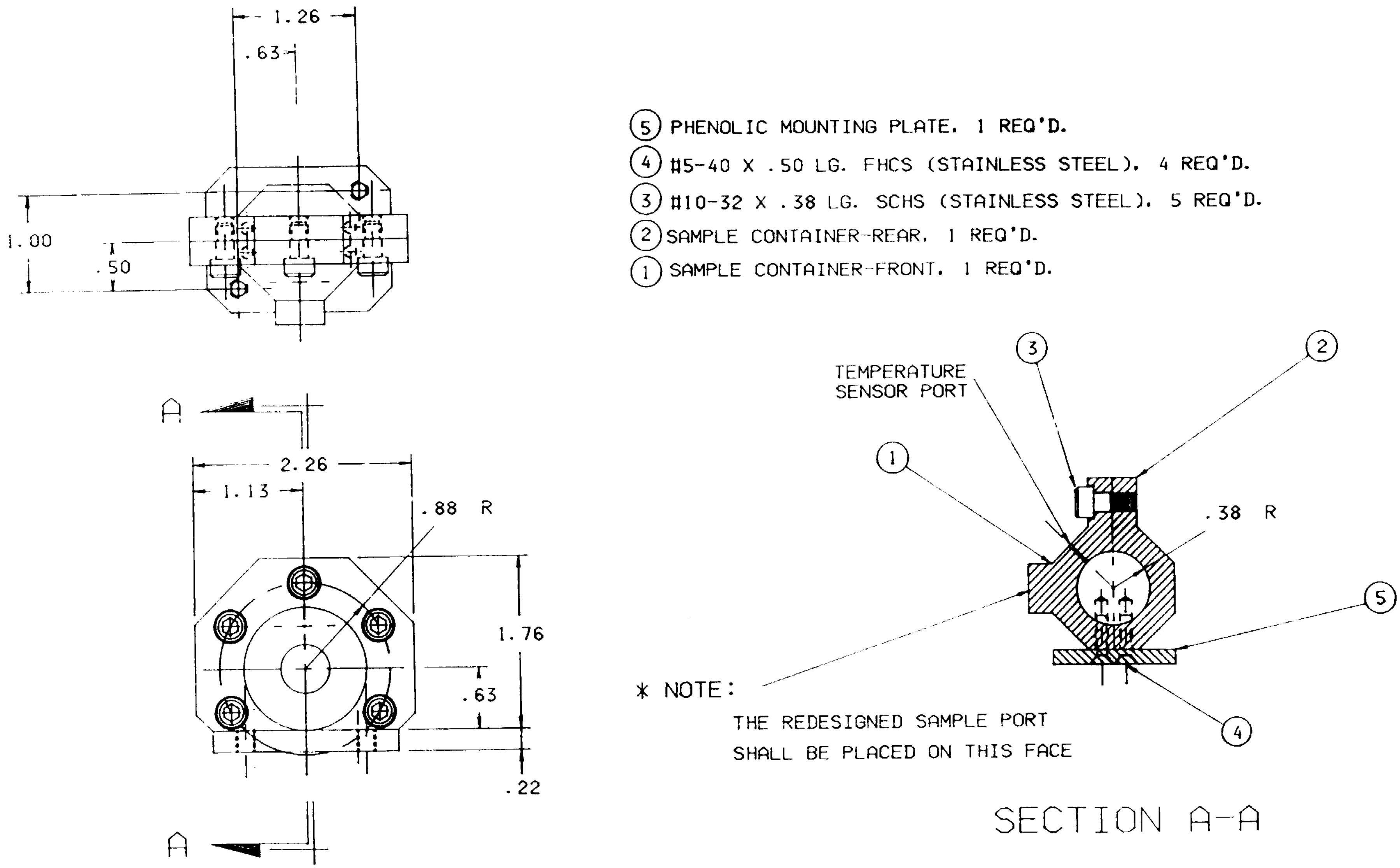


Figure 7 - **Teflon Fluid Sample** Container

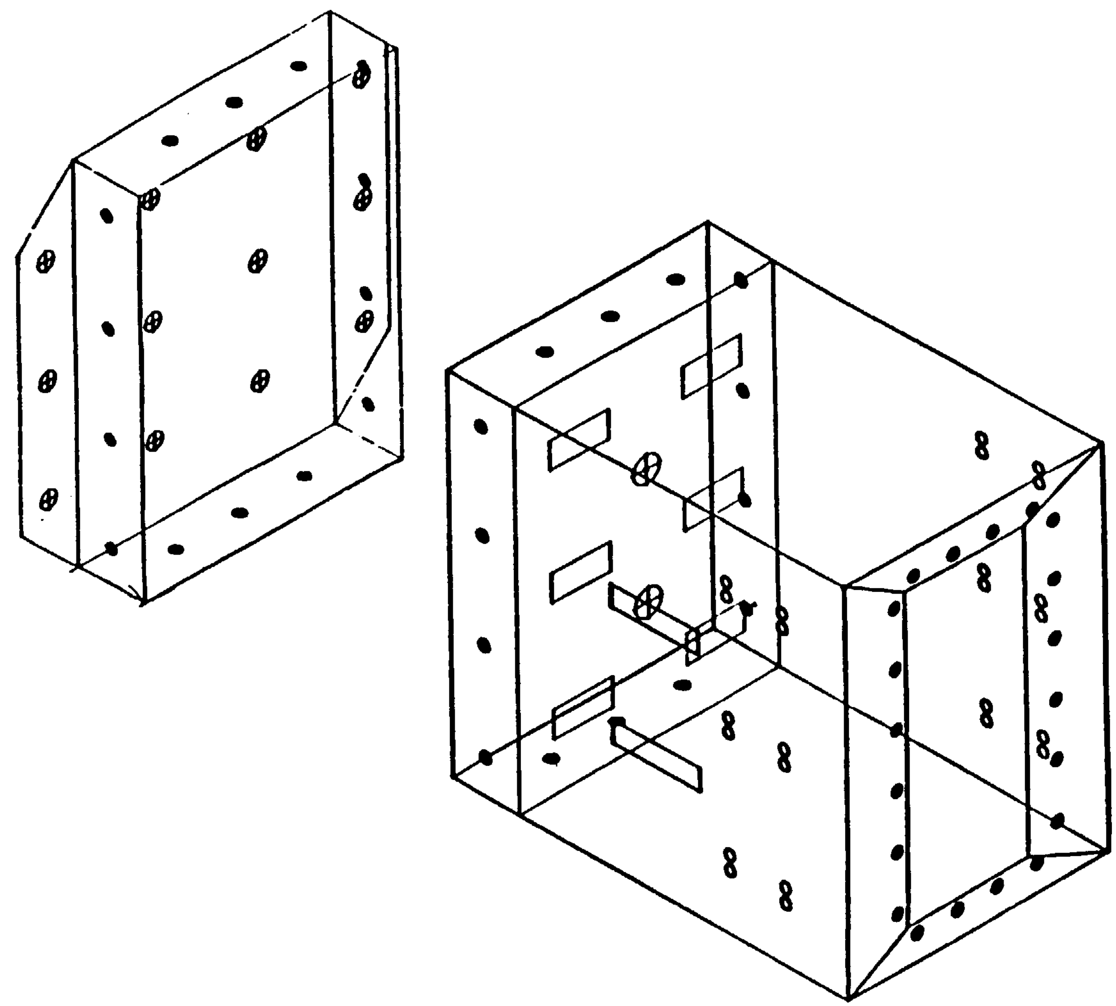


Figure 8 - Exploded View of Inner Shell Containment and Structural System
(shows both the base plate, box and end panel)

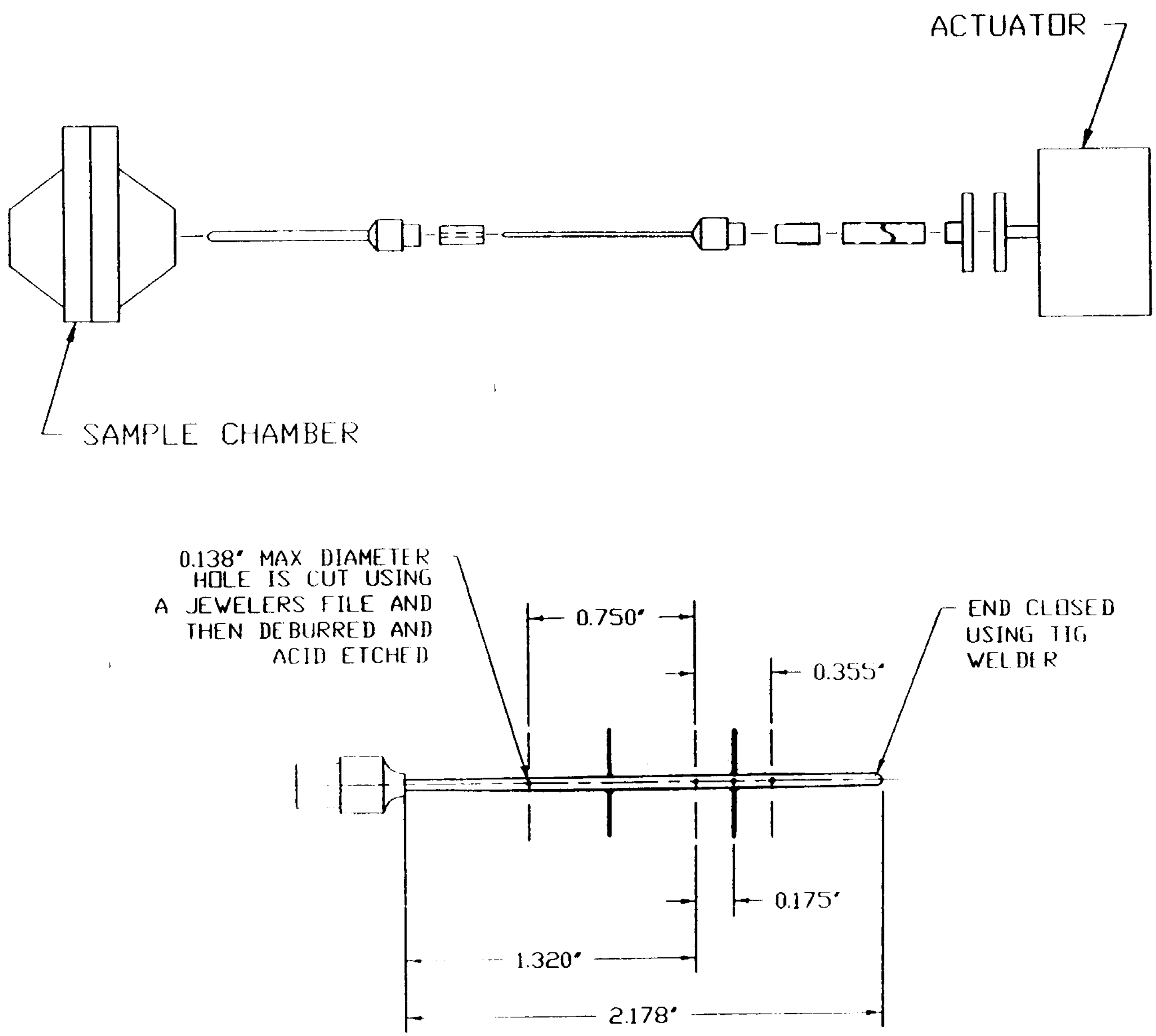


Figure 9 - **Fluid Sampling Mechanism And Enlarged View of Sample Tube**

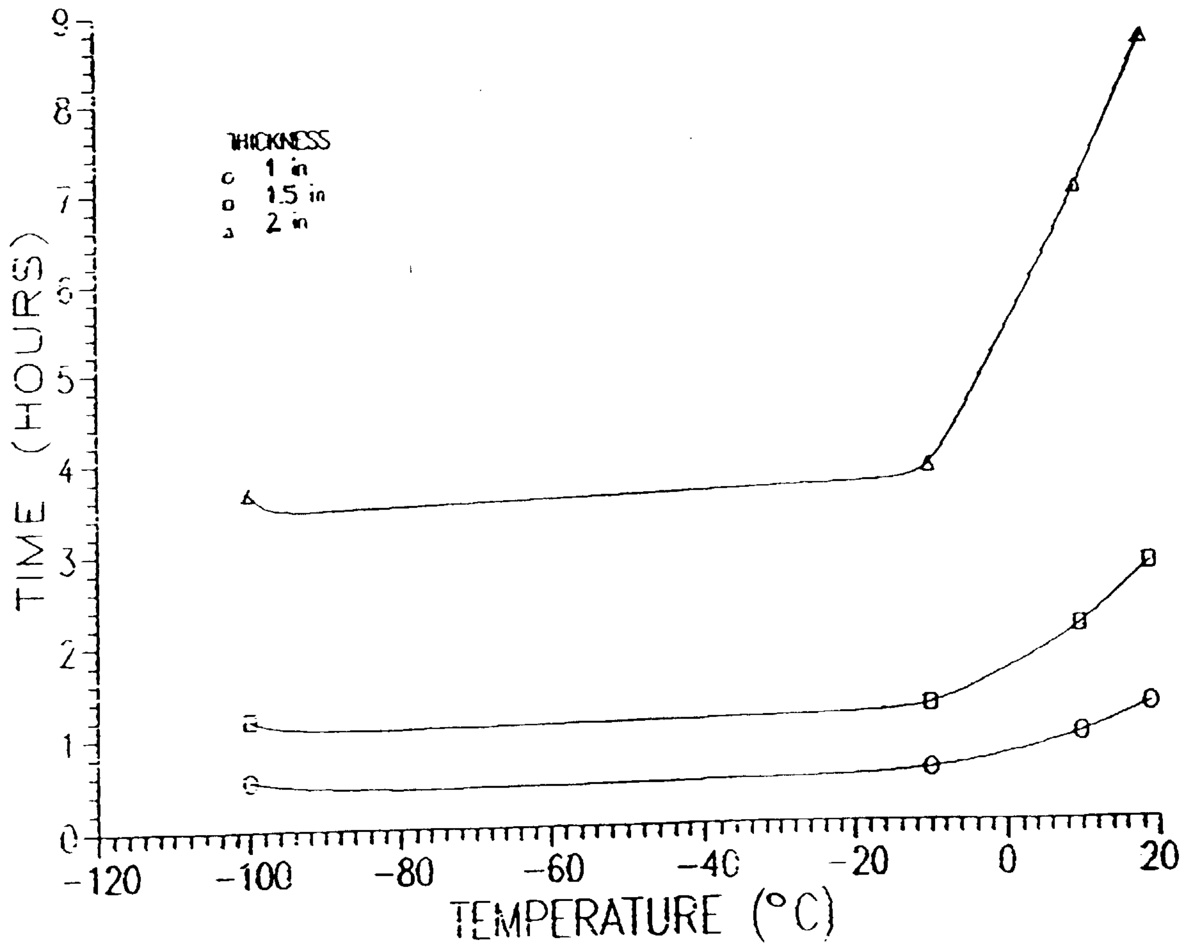


Figure 10 - Cooling Times For Various Insulation Thicknesses

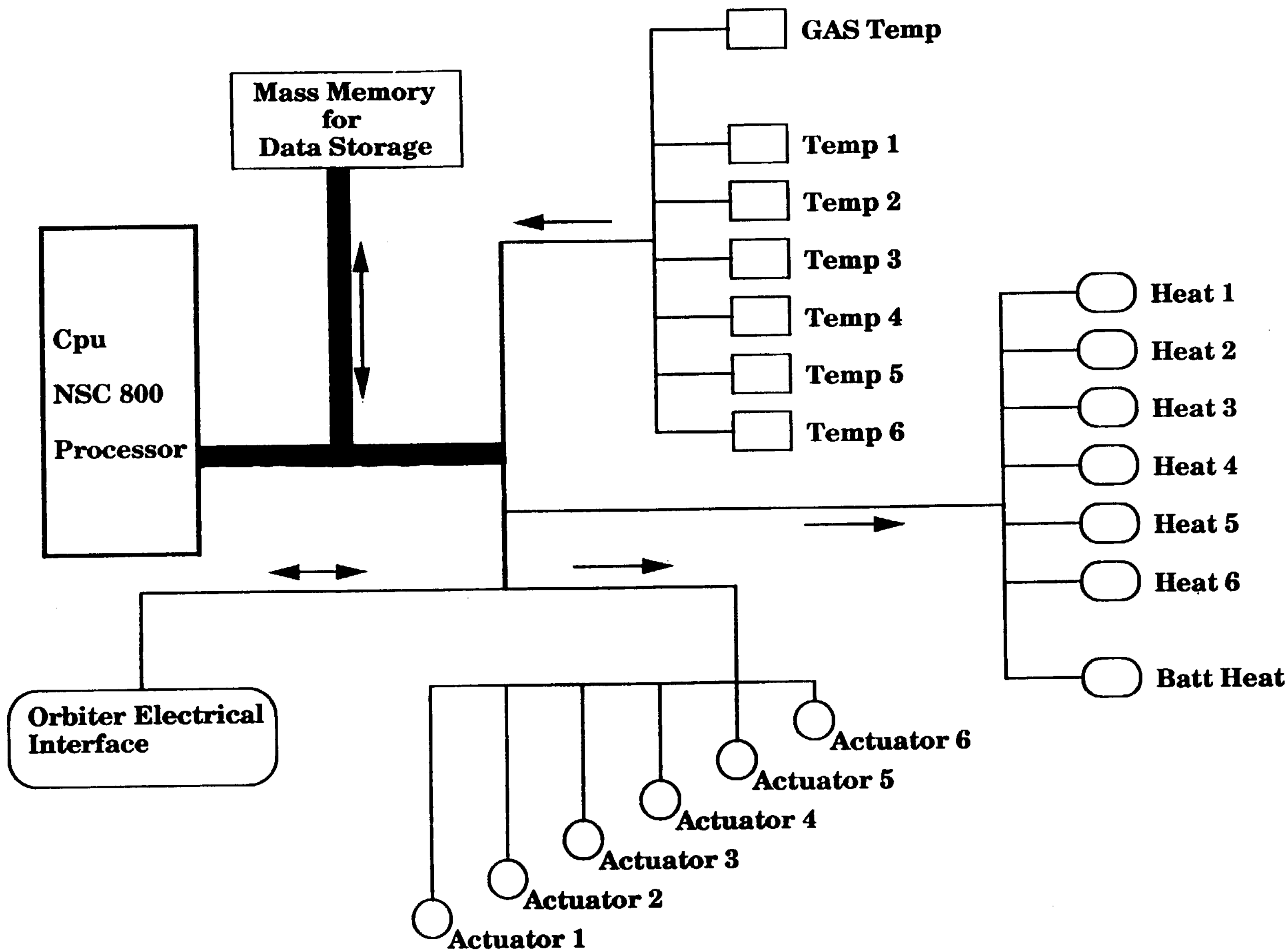


Figure 11 - Schematic Of Controller Architecture

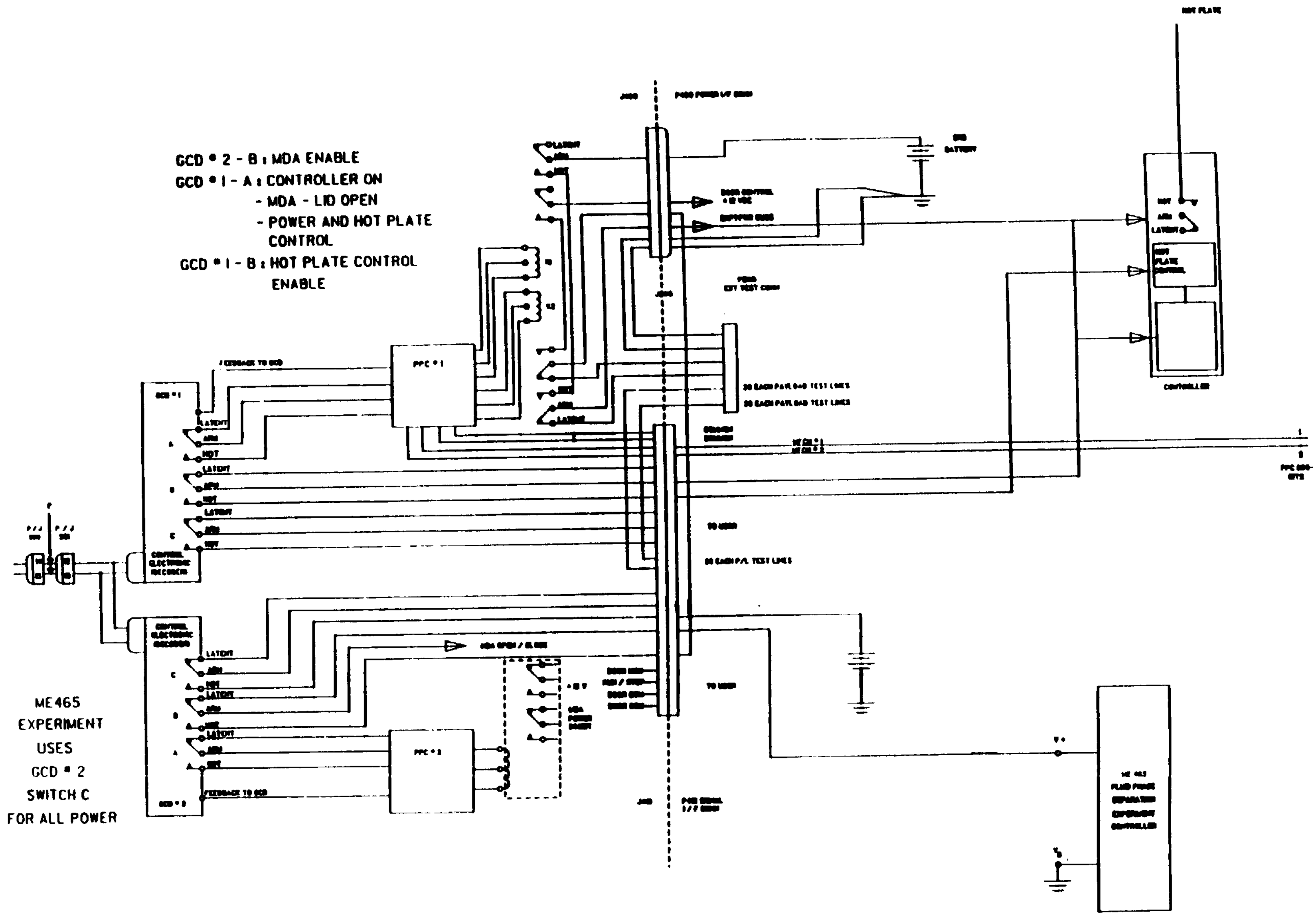
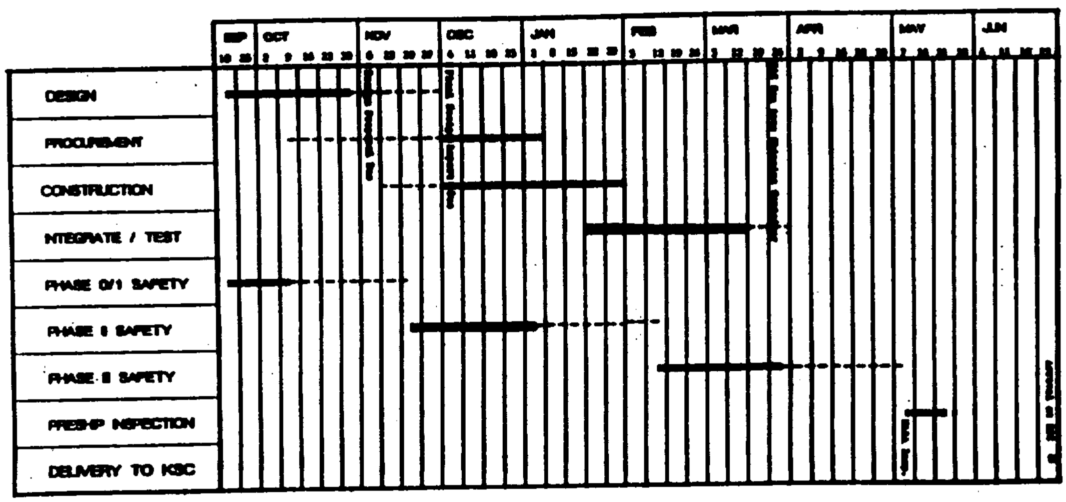


Figure 12 - Schematic Of Interface Of FPS Experiment With Orbiter



- **Optimized design for the FPS Experiment (began preliminary design September, 1989 and finished design May, 1990)**
- **Use fast track method for fabrication of flight hardware (anticipate completion by July, 1990)**
- **Begin testing and qualifying, summer of 1990**
- **Integration of experiment into GAS can by Sepetember, 1990**
- **Delivery to NASA in November, 1990**
- **Fly on STS-42 in April, 1991**

Figure 13 - FPS Experiment Time Line

BUDGET

COMPONENT	MATERIAL COST	LABOR COST	QTY	TOTAL COST
Teflon Octahedron	2.00 ea.	60.00 ea.	6	372.00
Sampling Mechanism				
Stainless Steel IV	3.00 ea.		6	18.00
1/16in Stainless Steel Tubing & Fittings	57.00 ea.		6	342.00
Phenolic Material	1.00 ea.	10.00 ea.	6	66.00
Teflon Gasket	17.00 ea.		6	102.00
Structural Frame				
Outer	50.00	80.00	1	130.00
Inner Housing	75.00	160.00	1	235.00
Fastners	25.00/100		26	6.00
Teflon Gasket	34.00	20.00	1	54.00
Teflon Sheet	160.00			160.00
Insulation	6.00			6.00
Fliters (7 micron)	35.00 ea.		2	70.00
D-Type Connector	25.00 ea.		2	50.00
Heaters	15.00 ea.		36	540.00
Thermocouple	53.00 ea.		6	318.00
Battery	15.00 ea.		2	30.00
Misc. Electrical				50.00
Assembly				240.00
Testing				100.00
TOTAL COST				$ 2,461.00

Figure 14 - FPS Experiment Estimated Budget

SAFETY REPORT

GAS PAYLOAD SAFETY MATRIX

PAYLOAD	PAYLOAD ORGANIZATION	DATE	PAGE
G - CONCAP 2-Fluid Phase		4 DEC 89	

HAZARD GROUP / SUBSYSTEM	COLLISION	CONTAMINATION	CORROSION	ELECTRICAL SHOCK	EXPLOSION	FIRE	TEMPERATURE EXTREMES	RADIATION					
BIOMEDICAL													
RADIATION													
STRUCTURES	X												
ELECTRICAL					X	X							
ENVIRONMENTAL CONTROL													
HUMAN FACTORS													
HYDRAULICS													
MATERIALS			X										
MECHANICAL													
OPTICAL													
PRESSURE SYSTEMS													
PYROTECHNICS													

GAS HAZARD LIST

PAYLOAD	SUBSYSTEM	DATE
CONCAP 2-Fluid Phase Sep. Exp.	MULTIPLE, AS LISTED	4 DEC 89

HAZARD GROUP	HAZARD TITLE	APPLICABLE SAFETY REQUIREMENT
COLLISION G - F1	STRUCTURES, MECHANICAL Failure of support structures.	NSTS 1700.7B 206- 208.1 208.2-208.3
CONTAMINATION CORROSION G- F2	MATERIALS Release of contaminating or corrosive materials	206- 209.1
EXPLOSION G- F3	ELECTRICAL Rupture of Battery	206- 213.2
FIRE, TEMPERATURE EXTREMES G- F4	ELECTRICAL Thermal Runaway	206 213.1 213.2

GAS PAYLOAD HAZARD REPORT

GAS PAYLOAD HAZARD REPORT	No. G-
PAYLOAD: CONCAP 2-Fluid Phase Separation Experiment	PHASE
SUBSYSTEM: STRUCTURES — HAZARD GROUP: COLLISION	DATE: 4 DEC 1989

HAZARD TITLE: Failure of Support Structures

APPLICABLE SAFETY REQUIREMENTS:

206- Failure Propogation
208.1- Structural Design
208.2- Emergency Landing Loads
208.3- Stress Corrision

HAZARD CATEGORY	
	Catastrophic
X	Critical

DESCRIPTION OF HAZARD: Failure of experiment support plate, failure of experiment structure on experiment support plate or failure of internal support structure when exposed to launch or landing conditions.

HAZARD CAUSES:

1. Design inadequate to withstand launch, space, and/or landing loads.
2. Failure of adjoining experiments.
3. Use of defective, improper, or improperly manufactured materials.
4. Stress corrosion.

HAZARD CONTROLS:

1. Properly sized and inspected bolts, screws, or other fasteners.
2. Safety factor of 1.4.
3. All joints properly constructed and inspected.

SAFETY VERIFICATION METHODS:

STATUS OF VERIFICATION:

PHASE III APPROVALS		
	GAS P/L Manager	GAS Safety Officer
	GAS Project Manager	STS

GAS PAYLOAD HAZARD REPORT

No. G-

PHASE

PAYLOAD	CONCAP 2- Fluid Phase Separation Experiment
SUBSYSTEM	MATERIALS
HAZARD GROUP	CORROSION
DATE	4 DEC 1989
HAZARD TITLE	Release of corrosive materials

APPLICABLE SAFETY REQUIREMENTS:

206- Failure Propogation
209.1- Hazardous Materials

HAZARD CATEGORY	
	Catastrophic
X	Critical

DESCRIPTION OF HAZARD:

Rupture of sample containers resulting in release of corrosive materials.

HAZARD CAUSES:

1. Rupture of sample containment vessels.
2. Contraction/expansion of sample vessel and sample fluid.
3. Fire resulting in sample vessel damage.

HAZARD CONTROLS:

1. Expansion cavity.
2. Multiple levels of containment.
3. Shrink wrap around containers.
4. Structural mounting of vessels.
5. Non-mettallic vessels.
6. Containment vessels made of approved material for experimental fluid.
7. Insulation could absorb some spilled fluid.

SAFETY VERIFICATION METHODS:

STATUS OF VERIFICATION:

PHASE III APPROVALS		
	GAS P/L Manager	GAS Safety Officer
	GAS Project Manager	STS

GAS PAYLOAD HAZARD REPORT

GAS PAYLOAD HAZARD REPORT	No. G-
PAYLOAD: CONCAP 2- Fluid Phase Separation Experiment	PHASE
SUBSYSTEM: ELECTRICAL / HAZARD GROUP: EXPLOSION	DATE: 4 DEC 1989
HAZARD TITLE: Rupture of battery	

APPLICABLE SAFETY REQUIREMENTS:

206- Failure Propogation
213.2- Electrical System, Batteries

HAZARD CATEGOR	
	Catastrophic
X	Critical

DESCRIPTION OF HAZARD:

Batteries are ruptured creating corrosive materials and shrapnel resulting in damage to the orbiter.

HAZARD CAUSES:

1. Overheating of battery due to heater runaway, polarity reversal, or short circuit.
2. Overpressurization of battery caused by outgassing.
3. Explosion of hydrogen and oxygen buildup created by short circuit.
4. Damage to batteries created by structural damage during ascent/descent.
5. Use of corrosive or otherwise hazardous electrolytes.

HAZARD CONTROLS:

1. Shrink wrap of all batteries.
2. Use of flight approved battery.
3. Multiple containment levels.
4. Use of bus board to reduce fire hazards.

SAFETY VERIFICATION METHODS:

STATUS OF VERIFICATION:

PHASE III APPROVALS	GAS P/L Manager	GAS Safety Officer
	GAS Project Manager	STS

GAS PAYLOAD HAZARD REPORT

GAS PAYLOAD HAZARD REP...	No. G-
PAYLOAD: CONCAP 2- Fluid Phase Separation Experiment	PHASE
SUBSYSTEM: ELECTRICAL — HAZARD GROUP: FIRE, THERMAL RUNAWAY	DATE: 4 DEC 1989

HAZARD TITLE: Thermal runaway

APPLICABLE SAFETY REQUIREMENTS:

206- Failure Propogation
213.1- Electrical Systems, General
213.2- Electrical Systems, Batteries

HAZARD CATEGOR	
	Catastrophic
X	Critical

DESCRIPTION OF HAZARD:

Failure of heater elements resulting in potential fire hazard or a short circuit contacting flammable material.

HAZARD CAUSES:

1. Malfunction of heater elements.
2. Malfunction of temperature control monitors.

HAZARD CONTROLS:

1. Use of non-flammable elements adjoining batteries and/or heater elements.
2. Properly inspected wiring and heaters.
3. Multiple containment levels.
4. Use of a Nitrogen atmosphere.

SAFETY VERIFICATION METHODS:

STATUS OF VERIFICATION:

PHASE III APPROVALS		
	GAS P/L Manager	GAS Safety Officer
	GAS Project Manager	STS

RESUMES

LAURA JO BLOUNT

EXPERIENCE

<u>Teaching Assistant</u>, Fall 1989
Department of Mechanical Engineering
University of Alabama in Huntsville
- Graded papers for the Heat and Mass Transfer class

<u>Metallographer</u>, Summer 1988
Department of Mechanical Engineering
NASA/University of Alabama in Huntsville
- Cast and polished flight specimens from a microgravity laser-welding experiment.
- Examined specimens under a microscope which had photographic capabilities.

<u>Research Assistant</u>, Summer 1987
Department of Mechanical Engineering
NASA/University of Alabama in Huntsville
- Established and reviewed data from a crystal hollography experiment.
- developed photographs and aided computer analysis programs.

<u>Medical Records Clerk</u>, Summer 1986
Department of Medical Records
University of Alabama in Huntsville Medical Clinic
- Posted doctor's dictation in patient's medical charts.
- Filed charts.
- Pulled charts for the next day's schedule.

EDUCATION

<u>B.S.E. Mechanical Engineering</u>
University of Alabama in Huntsville, expected December 1989.

PROFESSIONAL ORGANIZATIONS

American Society of Mechanical Engineers, Associate Member

ALAN L. DANIEL

EXPERIENCE

Mechanical Engineer, March 1988 - September 1989
Essex Corporation
Huntsville, AL 35806

- Responsible for design and development of two out three of the Maintance Trainers on the Integrated Avionics at the E6-A program.
- Lead Engineer on the integration between Boeing, Essex and Rediffusion Simulation Limited with all Avionic Trainers produced by Essex.
- Responsible for design and analysis work on the end effector on the Remote Manipulator System to be used by NASA in the Neuytral Buoyancy Simulator.
- Lead Engineer on BDM Autobus contract, responsible for all drawings and design of card cage and container which are to be used in military vehicles
- Certified to dive in the Neutral Buoyancy Simulator on RSA, have dived in support of the Hubble Space Telescope Program.

Engineering Aide, Summer 1987
E. Wayne McCain Boiler and Engineering Company
Birmingham, Alabama

- Performed tests evaluations on the boiler systems on RSA.
- Performed various studies and experiments on the boilers to determine their efficiency.

Intake Officer, June 1986 - June 1987
Madison County Juvenile Court System
Huntsville, Alabama 35811

- Responsible for processing all juvenile offenders brought to the Madison County Detention Home.

EDUCATION

B.S. Mechanical Engineering
University of Alabama in Huntsville, expected Fall 1989.

B.S. Applied Mathematics
Auburn University, June 1986

A.S. Mathematics
Calhoun Community College, August 1985

PROFESSIONAL ORGANIZATIONS

American Society of Mechanical Engineers

JAMES W. HANDLEY

EXPERIENCE

Cooperative Education Student, June 1987 - September 1989
Intergraph Corporation
Huntsville, AL 35807
-Responsible for design and drafting of various parts used on Intergraph computer systems and on line production systems.

Sales Clerk, June 1986 - December 1987
Rogers Department Store
Decatur, AL 35601
-Part time sales clerk responsible for displays and selling merchandise.

Data Entry Clerk, June 1984 - September 1986
Wheeler Basin Regional Library
Decatur, AL 35601
-Part time computer data base entry operator, placing books and patrons on existing data base files and creating new files.

EDUCATION

B.S. Mechanical Engineering
University of Alabama in Huntsville, expected Winter 1990.

HONORS

Pi Tau Sigma Mechanical Engineering Honorary, President
Alpha Lambda Delta Freshman Honorary, Secretary
Tau Beta Pi Engineering Honorary Society, Cataloguer
Phi Kappa Phi National Junior Academic Honorary
Omicron Delta Kappa National Leadership Honorary
Who's Who Among American Universities and Colleges
Outstanding College Students of America
The National Dean's List (Two years)
All-American Scholar

PROFESSIONAL ORGANIZATIONS

American Society of Mechanical Engineers

SCHOLARSHIPS

Decatur Scholarship
UAH Leadership Scholarship
UAH Student Affairs Scholarship (Two years)
William R. Gillies Society of Manufacturing Engineers Scholarship

TERESA W. NEAL

EXPERIENCE	Aerospace Engineer (Co-op), January 1987-present U.S. Army Missile Command, RD&E center -performed tasks on the composite materials used for the nozzle section of missile systems. -serve as the service life program leader of the nozzle materials -assisted in modifying the test series run for the service life program and designed the new test fixtures for this test series -modified programs written in FORTRAN and BASIC used for data analysis -ran uniaxial tensile tests on solid rocket propellant from various U.S. missile systems -ran service life codes with the test results
EDUCATION	B.S. Mechanical Engineering, expected March 1990 University of Alabama in Huntsville
PUBLICATIONS	Neal, Teresa W., Mechanical Property "Characterization for the MLRS Nozzle Stored One Year", U.S. Army Missile Command, RD&E, Sept. 1989, RD-PR-89-1. Fisher, Jamie; Neal, Teresa; and Cook, Felicia "Baseline Mechanical Properties Characterization of the HELLFIRE Phenolic Nozzle", U.S. Army Missile Command, RD&E, July 1989 (submitted), RD-PR-89-2.
HONORS	Cooperative Education Program National Champion Crew 1988 (UAH)

BRUCE R. PETERS

EXPERIENCE

Research Assistant, December 1985 - present
Department of Mechanical Engineering
University of Alabama in Huntsville
- Incorporated fiber optics into specialized ultrasonic systems for nondestructive evaluation.
- Conducted applied research in holographic interferometry.
- Developed fiber optic systems for remote sensing, precision measurement and optical inspection.
- Project manager for student designed Fluid Phase Separation Experiment to be flown on the space shuttle.

Teaching Assistant, January-June, 1989
Department of Mechanical Engineering
University of Alabama in Huntsville
- Instructor for junior level Dynamics course.
- Lab instructor for junior level Soil Mechanics course.

Consultant, Summer 1985, Fall 1986, Summer 1987
AT&T Bell Laboratories
Murray Hill, New Jersey 07974
- Participated in design of a prototype optical fiber interferometer (applied for patent).
- Conducted innovative research into laser generated ultrasound.

Research Assistant, January-December, 1985
Department of Civil Engineering
University of Wisconsin in Milwaukee
- Holographic studies using triple pulsed ruby laser system.
- Developed fiber optic coupling device for high energy laser.

Teaching Assistant, September-December, 1984
Department of Civil Engineering
University of Wisconsin in Milwaukee
- Lab instructor for Strength of Materials course.

Surveyor's Assistant, summer 1982
Milwaukee Metropolitan Sewage District
Milwaukee, Wisconsin 53201
- Survey and inspection of sanitary and drainage control projects.

EDUCATION

Ph.D. Engineering Mechanics and Applied Optics
University of Alabama in Huntsville, expected Winter 1989

M.S. Engineering Mechanics
University of Wisconsin in Milwaukee, December 1985

B.S. Civil Engineering
University of Wisconsin in Milwaukee, May 1984

B.S. Architecture
University of Wisconsin in Milwaukee, May 1982

PUBLICATIONS

Burger, C.P., Dudderar, T.D., Gilbert, J.A., Peters, B.R., Smith, J.A., Raj, B., "Thermal acousto-optic excitation for non-contacting NDE, Proc. of the 1986 Spring Conference on Experimental Mechanics, Society for Experimental Mechanics, New Orleans, Louisiana, June 8-13, 1986, pp. 680-685.

Burger, C.P., Dudderar, T.D., Gilbert, J.A., Peters, B.R., Smith, J.A., Raj, B., "Laser excitation through fiber optics for NDE," Journal of Nondestructive Evaluation, 7(1): 57-64 (1987).

Gilbert, J.A., Johnson, H.S., Peters, B.R., Ruggiero, R.M., "Optical systems for nondestructive evaluation," Proc. of the Nondestructive Evaluation for Aerospace Requirements Conference, Huntsville, Alabama, August 26-27, 1987.

Burger, C.P., Dudderar, T.D., Gilbert, J.A., Smith, J.A., Peters, B.R., "The use of fiber optic interferometry to sense ultrasonic waves," ISA Transactions, 28(2): 51-55 (1989).

Gilbert, J.A., Burger, C.P., Dudderar, T.D., Smith, J.A., Peters, B.R., "Detection and evaluation of ultrasonic waves using single mode optical fiber," Proc. of the VI International Congress on Experimental Mechanics, Portland, Oregon, June 5-10, 1988.

Dudderar, T.D., Burger, C.P., Gilbert, J.A., Smith, J.A., Peters, B.R., "Fiber optic sensing for ultrasonic NDE," accepted for publication by the Journal of Nondestructive Evatuation, 1988.

Dudderar, T.D., Gilbert, J.A., Johnson, H.S., Peters, B.R.,"The use of singlemode fiber-optics for illumination and wavefront transmission in holography and holo-interferometry," Proc. of the 1989 Spring Conference on Experimental Mechanics, Society for Experimental Mechanics, Cambridge, Massachusetts, May 28-June 1, 1989, pp. 765-770.

Peters, B.R., Gilbert, J.A., Dudderar, T.D., "The use of fiber-optics for TAP-NDE," Proc. of the 1989 Spring Conference on Experimental Mechanics, Society for Experimental Mechanics, Cambridge, Massachusetts, May 28-June 1, 1989, pp. 792-797.

HONORS

ASNT 1987 Fellowship Student Research Fellowship
Physical Sciences Award Sigma Xi Student Research Day, 1988
Tau Beta Pi Engineering Honary Society
Phi Eta Sigma Freshman Honary Society

PROFESSIONAL ORGANIZATIONS

American Society for Nondestructive Testing
American Society of Civil Engineers
American Society of Mechanical Engineers

GUY T. ROBERTS

EXPERIENCE

Associate Process Engineer, November 1984 - present
Onan Corporation
Huntsville, Alabama 35807

- Provide technical services support to manufacturing.
- Perform capital equipment analysis, justification of expenditures and follow with procurement of equipment.
- Originate and develop processes, improve processes and strive for cost reductions.
- Determine tooling, gaging and fixturing requirements.

- Current areas of responsibility:
  - a) Cylinder Head machining line - Cummins "A" diesel engine
  - b) Crankshaft machining line - Cummins "A" diesel engine
- Past areas of responsibility:
  - a) Connecting Rod machining line - Cummins "A" diesel engine
  - b) Miscellaneous machining department - Onan gas engine
  - c) Fabrication department - Cummins "A" and Onan engines

Supervisor of Tool Design, December 1977 - November 1984
Onan Corporation

- Supervised tool design and print services groups.
- Trained personnel, scheduled duties, evaluated performances and made recommendations for merit raises.
- Programed computer numerical control (CNC) machines, established machine cutter lists and operator instruction sheets for the CNC machines.

Tool Designer, September 1974 - December 1977
Onan Corporation

- Developed concepts and detailed designs for dies, jigs, fixtures, gages, and special machinery.
- Designed hydraulic and pneumatic circuits for use in automated fixturing and machinery.

Draftsman, August 1974 - September 1974
GTE Automatic Electric
Huntsville, Alabama

- Produced detailed product drawings from engineering sketches.

Draftsman, April 1972 - August 1974
Cutler-Hammer
Arab, Alabama

- Created detail drawings, assembly drawings, and dimensional drawings.

Contract Tool Designer, 1976 - 1980

- Contracted design of progressive dies, blanking dies, form dies, and draw dies for sheet metal fabrication to various Tool and Die shops in the Huntsville, Alabama area.

EDUCATION

B.S. Mechanical Engineering
University of Alabama in Huntsville, expected May 1990

ROBERT K. STRIDER

EXPERIENCE

<u>Engineer Trainee</u>, Sept. 1986-present
U.S. Army TMDE Support Group
Redstone Arsenal, Alabama
- -Worked in systems engineering group dealing with calibration equipment
- -Formed database for all TMDE equipment
- -Evaluated items for procurement
- -Worked with many different aspects of physical calibration

<u>Sales Associate</u>, Aug. 1985-present
Parisian Department Store
Huntsville, Alabama
- -Salesperson for men's clothing
- -Authorizer of credits and sales

<u>Lawn Specialist</u>, Jan. 1985-July 1985
Chemlawn Services Corporation
Hunstville, Alabama
- -Responsible for complete fertilization and weed control of residential and commercial lawns

<u>Agribusiness Teacher</u>, Aug. 1979-Nov. 1984
Hazel Green High School
Hazel Green, Alabama
- -Responsible for vocational training of high school students in production agriculture and all shop related areas such as welding, wood working, electricity, building construction, drafting, and mechanics
- -Maintained a work experience program for each student
- -Supervised 5 student teachers
- -Taught adult night classes in electricity, welding, and woodworking

<u>Other Employment</u>
- -<u>Wildlife Management Worker</u>, June-July 1979
- -<u>Agribusiness Teacher (Special Services)</u>, Nov. 1978-May 1979
- -<u>Substitute Agribusiness Teacher</u>, Aug.-Oct. 1978

EDUCATION

<u>B.S.E. MECHANICAL ENGINEERING</u>
University of Alabama, Huntsville, December 1989

<u>M.S. AGRIBUSINESS EDUCATION</u>
Alabama A & M University, Normal, AL, May 1983

<u>B.S. AGRIBUSINESS EDUCATION</u>
Auburn University, Auburn, Alabama, August 1978

HONORS

Listed in Outstanding Young Men of America for 1985
Former President and Sight Chairman of Hazel Green-Meridianville Lions Club
Kappa Delta Pi Education Honor Organization, Auburn University, 1978
Honorary State Farmer Degree, Future Farmers of America 1984

MICHAEL T. WILLIAMS

EXPERIENCE

<u>Assoc. Process Engineer</u>, Dec. 1988 to present
Onan Corporation, Huntsville, Alabama (May, 1977 to present)
Responsibilities:
- -Capital Equipment analysis, justification and procurement
- -Develop machining processes to hold required print tolerances
- -Select and purchase required tooling and gaging
- -Write processes and inspection instructions
- -Develop CNC programs
- -Provide manufacturing support necessary to assure production requirements

<u>Senior Tool Designer</u>, (CNC Programmer) May 1977 to Dec. 1988
Responsibilities:
- -Provide highly capable designs and drafting services for new dies, jigs, fixtures,gages, cutting tools and special machinery, etc.
- -Specify standard components such as bushings,clamps, die sets, etc., for use in tool designs. Initiate vendor contact for assistance in specifying said comppnents.
- -Specify materials to be used in tool designs; i.e., aluminum, brass, steels and hardness etc.
- -Examine tool drawings made by fellow tool designers for inaccuracies and to assure desired results are accomplished.
- -Assist Tool Room in evaluation of machine setups to produce required designs.
- -Develop CNC programs.

EDUCATION

<u>Associated Degree in Applied Science</u>
Calhoun Community College Technical School, May 1977
Major in Technical Drafting

<u>Bachelor of Science Degree in Engineering</u>
University of Alabama in Huntsville, expected Spring 1990.
Major in Mechanical Engineering

DENNIS RAY WINGO

EXPERIENCE

Research/Engineering Assistant, January 1988, current.
University of Alabama in Huntsville 35899.
-Center for Plasma and Aeronomy Research
- -Working with Shuttle and Delta II payloads.
- -Wrote ethernet software for NASA (MSFC) AMPS breadboard.
- -Specify and procure test equipment for Consort program.

Engineering Technician, (Consultant) February-August, 1988
New Technology Inc. MSFC Huntsville Al.
- -Debug of the DRCC system for STS SSME telemetry routing.

Operations Engineer, June-November, 1987
Delores Press 1204 S. Glendale Ave, Glendale Ca. 91205.
- -Video tape operations for University Network.
- -Camera work for live programming.
- -DJ during live programming.

Test Engineer/Field Engineer, July 1985-June 1987
Alpharel Inc 765 Flynn Rd. Camarillo Ca. 91030.
- -Worked on the design and development team of the DSREDS/EDCARS engineering document archival system.
- -Subcontract engineering liaison to AT&T throughout development period at AT&T development labs in N.J. Installed first system at US army MICOM, Huntsville Al.
- -Worked in marketing dept on development of new market opportunities for Alpharel products.

Test Engineer, September 1984-July 1985
Ibis Systems Inc. 5775 Lindero Cyn. Rd. Westlake Ca. 91360
- -Worked on the development, debug and implementation of test equipment used to qualify the Ibis Winchester disk products installed on the Cray supercomputer.
- -Trained manufacturing techs and maintained in-house computers.

Test Engineer, April 1984-September 1984
Symbolics Inc. 9600 Desoto Chatsworth Ca.
- -Debugged boards and systems for Symbolics 3600 Lisp Machines.

Member of Technical Staff, August 1983-April 1984
Remote Transmission Systems. 5839 Sebastion Rd. San Antonio Tx
- -Designed a two channel statistical multiplexer.
- -Helped design remote point of sale inventory controller for NCR cash registers.

Sr R&D Technician, April 1981-August 1983
Vector Graphic Inc. 500 N Ventu Pk. Rd. Thousand Oaks Ca. 91320.
- -Intermediate tech, debug digital logic boards and systems.
- -Senior Tech, Debug of complex logic boards and systems.
- -Supervisor Customer Support Repair, Organized new department and supervised six technicians.
- -Sr R&D tech, debugged new designs and wrote mfg. test plans.

Service Manager, June 1980-April 1981
Electrolux Inc. 1020 20th St. S Birmingham Al. 35205
- Service manager for Electrolux plus inside sales.

Engineering Technician, February 1980-June 1980
Space Vector Corp. 19631 Prairie St. Northridge Ca.
- Debug and environmental test of electronic subsystems used on Aries sounding rockets.

Sound Engineer, July 1979-February 1980
- free-lance work with sound boards for concerts.

Associate Field Engineer, August 1978-June 1979
Documation Inc. 205 Corporate East. Birmingham Al.
- Maintained 3000 line per minute impact line printers, high speed card readers and card punches.

EDUCATION

B.S. Physics and Mechanical Engineering, expected 1992
University of Alabama in Huntsville

Associate Degree in Communications Electronics, 1978
Area Vocational Center, Gardendale AL,

PUBLICATIONS

"Using the VME Bus for a Low Cost Spacecraft Data Bus", April 1989 IEEE Southeast Conference.

PROFESSIONAL ORGANIZATIONS

Institute of Electrical and Electronic Engineers. IEEE
American Society of Mechanical Engineers. ASME
Students for the Exploration and Development of Space. SEDS
Amateur Radio Satellite Organization. AMSAT

HONORS

First place winner for IEEE technical paper competition, Southeast Region 1989.