ENGINEERS' FORUM

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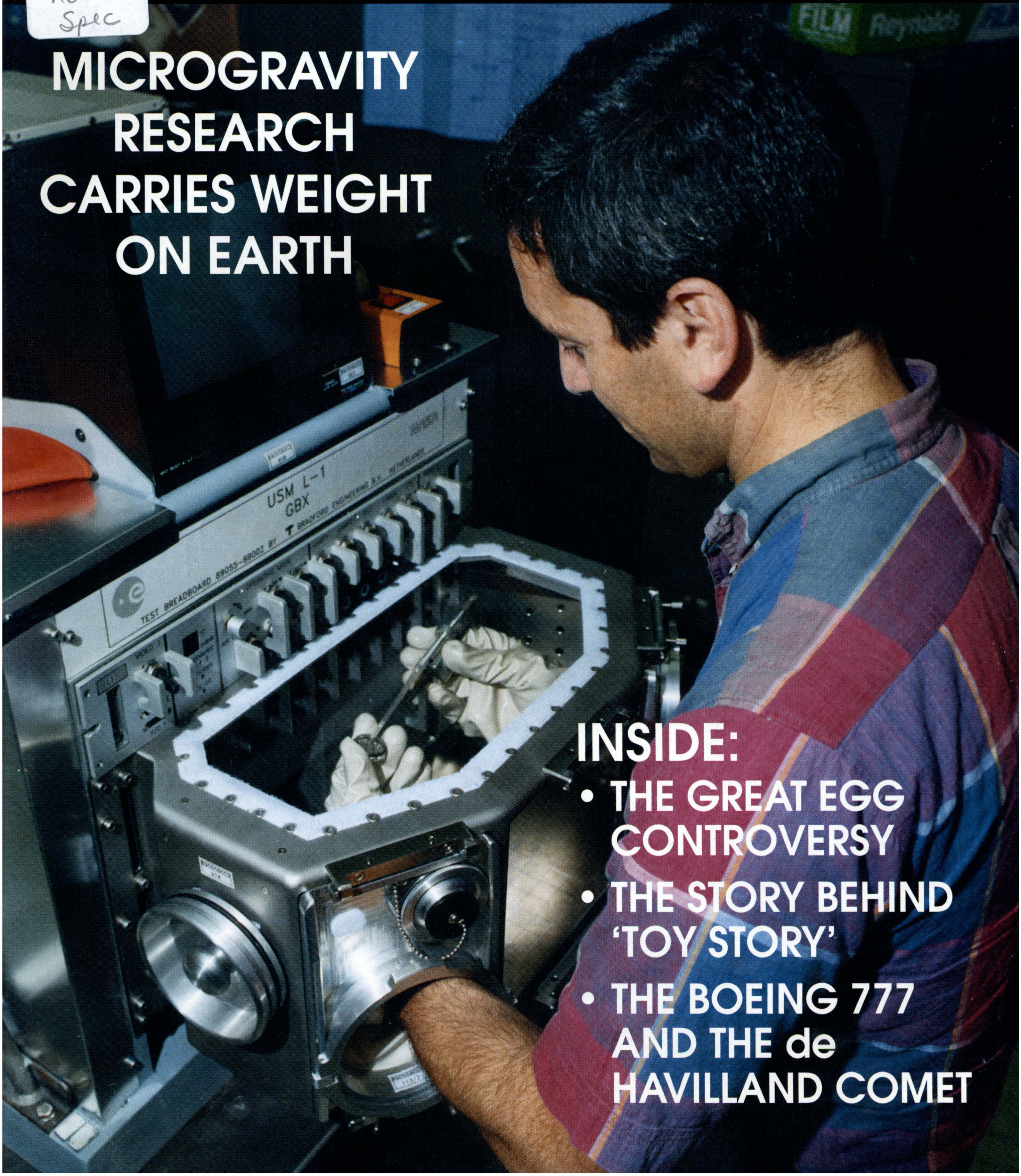


MICROGRAVITY RESEARCH CARRIES WEIGHT ON EARTH

INSIDE:

- THE GREAT EGG CONTROVERSY
- THE STORY BEHIND 'TOY STORY'
- THE BOEING 777 AND THE de HAVILLAND COMET

Letter from the **Editor** February 1996

THE INTERNET AND PROCRASTINATION

We've all faced it. We've all succumbed to its enticing, seductive tendrils. We've all kicked ourselves in the seat of the pants after doing poorly on a test because of it.

But for some unknown reason, re-organizing a closet, cleaning the room or playing on the computer becomes infinitely more important than studying for that Deforms test (which is worth a third of your grade, by the way) that is less than 12 hours away.

My friends, engineers, and countrymen, we have all prayed at the altar of procrastination. Unfortunately, we usually get sacrificed there, too.

Engineers are, however, genetically destined to procrastinate. As one of my professors so eloquently put it my freshman year: "You're all lazy! You need to be lazy to be good engineers."

Which is true. What other profession looks to do things cheaply, do them quickly, and only do them once? Lawyers? No. Doctors? Construction workers? Politicians? No. No. NO! Prostitutes? Well...

My point (point? oh yeah, the point) being engineers are almost pre-ordained to waste time some where along the line. They're so busy saving time elsewhere that it usually evens out.

What bothers me, though, is not the constructive acts of procrastination, such as working for an engineering magazine for little recognition and even less pay (but a hell of a lot of camaraderie and satisfaction, I'll grant you that!), but rather the non-constructive means with which we lead ourselves to distraction.

The sheer magnitude of high-tech gadgets which aid in doing nothing is overwhelming and amazing. Television, video games, e-mail, and the worst of them all: the Internet.

The sheer magnitude of high-tech gadgets which aid in doing nothing is overwhelming and amazing. Television, video games, e-mail, and the worst of them all: the Internet.

It is saddening that what should be our most creative scientific minds have become a generation of cyber-voyuers. Rather than interact with other people face-to-face or create something ourselves, we choose to lock ourselves in our rooms, chained to the CRT, surfing the 'net. I suppose they call it "surfing" to make it sound vaguely physical. But make no mistake, the only "ten" you'll be hanging will be your ten little digits tapping away on the keyboard.

It's so easy to have hours of your life sucked into the 'net. There is so much interesting crap to read in there. Unfortunately, it's just that: Crap. Not only is it interesting, but it is also worthless. There are home pages about low budget TV shows (and don't even get me started on TV as a voyeuristic device) nobody watches, home pages about Bullwinkle, bell-bottoms, socks and pants in the '80s, even home pages about home pages (I am not making this up).

We cruise the 'net with such intent, it's almost as if we think we might be able to find a link to the home page for the meaning of life.

Well, guess what. It's there. I've seen it. And guess what it says: "Site under construction."

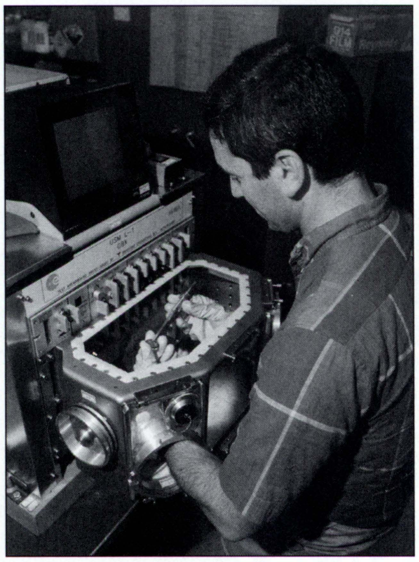
So, my friends, try to free yourselves from your electronic bonds (no pun intended) every once in a while. Do more activities outdoors. Take it from someone who has surfed the 'net and lived to tell about it: Live life, don't watch it pass by on somebody else's web page.

Of course, if you do happen to hop on the 'net, check out the improved website for the Engineers' Forum at

http://www.vt.edu:10021/eng/forum/index.html

Ray Easterling
Editor

On the **Cover**



Dr. Larry DeLucas of the University of Alabama in Birmingham, AL, practicing experiment operations in the microgravity glovebox facility, before the First United States Microgravity (USML-1) mission (STS-50) which flew in June 1992. Photo by Emmett L. Given, courtesy NASA.

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World Wide Web address:
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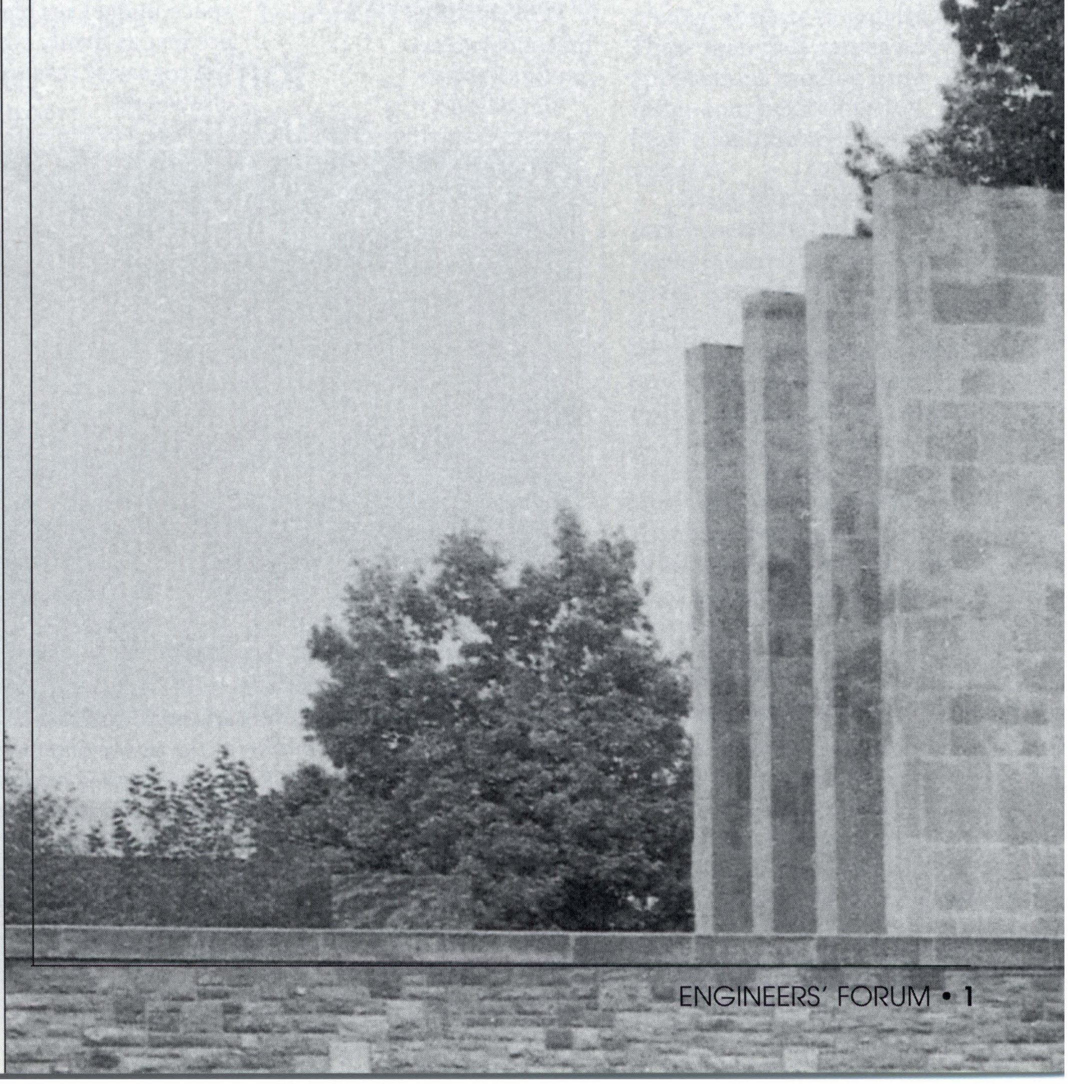
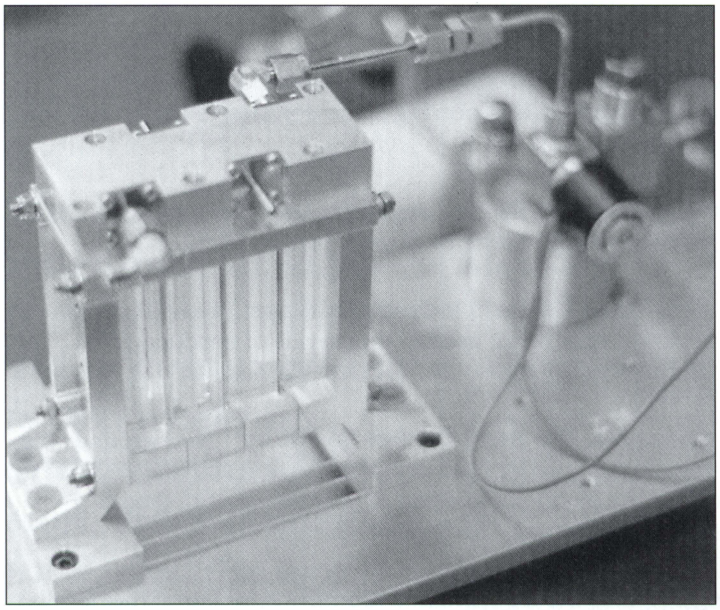


μg: Microgravity



Breadboard model of the Fluorinet Problem at right.

BY AL LOWAS

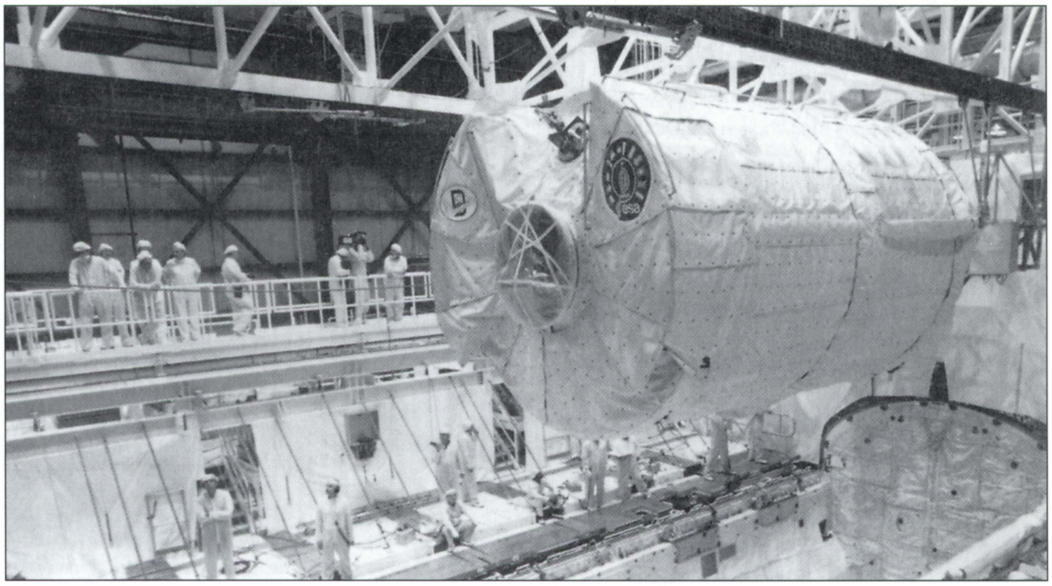
All photos courtesy NASA.

Problem: *Find the contact angles between stationary liquid Fluorinet and the walls of a Quartz rhombic prism in a gravitational field approximately one-thousandth of that on Earth.*

To most engineering students, this probably sounds like the fluid mechanics problem that — with any good fortune — will never come to be. To scientists of the National Aeronautics and Space Administration and the European Space Agency however, this may be a key to problems like designing more efficient fuel tanks to studying the flow of rain on windshields. And it is but one of many forms of microgravity research being conducted in space by these and other groups.

Over the past two decades, microgravity has become an increasingly important part of NASA's mission. It was a significant part of the Skylab program and now is the primary function of much of this program. Microgravity is also a prime reason for the development of a Space Station.

In fact, many space enthusiasts have come to believe the keys to solving problems such as AIDS and cancer lie in microgravity research — and if these solutions are found, it will be another decade before anyone has to worry about space budget problems again. Many other scientists however, are just as firmly convinced that nothing will ever come of microgravity research, and that the resources should be spent elsewhere.



Spacelab is ESA's contribution to the Space Shuttle Program. It contains various forms of pressurized habitable modules for conducting experiments in a shirt-sleeve environment, and other exposed payload modules (pallets) for experiments that do not need to be man tended. Many of the microgravity experiments take place in the pressurized section, within telephone-booth sized interchangeable racks. Spacelab missions are managed out of NASA's Huntsville Operations Support Center (HOSC) at Marshall Space Flight Center in Alabama.

So what, then, is microgravity research? What does it do? What are its limitations?

Microgravity Research, an Overview

Most people learn in their high school physics classes that space is "weightless." So why do scientists talk about microgravity? Actually, no object can be absolutely weightless because the gravitational field of the earth and other object extend indefinitely, although with greatly decreasing strength with increasing distance.

Ironically, what contributes most to the gravitational field of a space experiment, however, is the space vehicle itself. Having a fairly significant mass very close to the experiment, it creates a noticable gravitational field. Other contributing factors include moving objects onboard the space vehicle such as motors, centrifuges, and astronauts, and the position of the experiment with respect to the vehicle's center of gravity.

Care must be taken in mission planning to place the more sensitive microgravity experiments close to the vehicle's center of mass and far away from large moving parts. For all practical purposes, any gravitational field between one 1/1000 and 1/1000000 of the acceleration due to gravity on earth is considered acceptable for most microgravity experiments and is achievable with careful designing.

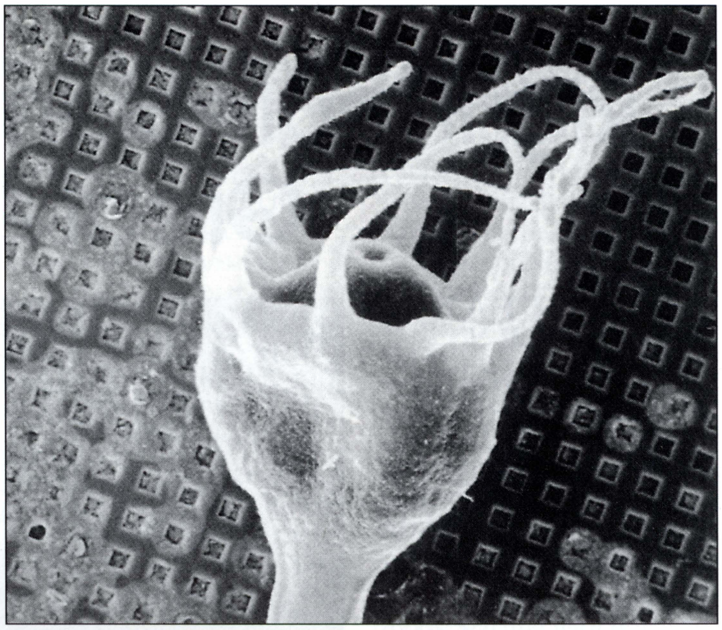
Similar microgravity situations are achievable on earth using drop towers, free-falling airborne experiments, and the like, but are usually impractical. The most significant limitation to these sorts of microgravity research is that they only allow for up to a few minutes of "weightless" conditions. In orbit, the time frame is much longer, for the most part limited only by the endurance of the space vehicle and its operators. This allows for much longer experiments such as those needed to crystallize materials, and for the repetition of experiments that is needed in any type of research.

What types of experiments can be conducted in microgravity?

Microgravity research has been used — and continues to be used — to research different disciplines from biology and medicine to fluid physics, materials technology, and physical chemistry.

In biotechnology, for example, experiments have been conducted in areas ranging from protein crystal growth to gravitational biology which determine the mechanisms by which organisms sense gravity and react to it. For example, previous microgravity experiments have found proteins that grow in long straight patterns on earth tend to grow in more erratic directions in space, while jellyfish swim linearly on earth, but in a circular motion while in space. These experiments have been used to study protein structures in order to create new medicines, and have begun to advance the understanding of such physical conditions as osteoporosis.

What contributes most to the gravitational field of a space experiment... is the space vehicle itself.



Sample photograph of a jellyfish experiment taken with a scanning electron microscope.

In the area of fluid physics, highly precise measurements of transport operations can be conducted without the interaction of a gravity field. Previous experiments in vaporization and condensation kinetics have greatly enhanced the knowledge and understanding of boiling in heat exchangers and the vaporization of water from lakes and rivers. Other experiments include studies of diffusion and thermodynamic properties of the critical point — studies impossible on earth.

The stability and dynamics of the solidification front, the line where molten material turns into solid form, and how temperature profiles are affected by the solidification parameters and convection, are some of the many materials science experiments that can be conducted in microgravity. This particular type of study is concerned with the properties of materials produced in a gravitational field and methods to create more pure materials in the relative absence of gravity. These materials can have applications ranging from faster computer chips to higher definition optical systems.

Many of us learned early that a match lit in space burns spherical rather than in the familiar "tear-drop" shape it has on Earth. Learning the reasons for this, and a subsequent greater understanding of combustion is a major focus of the physical chemistry types of microgravity experiments that have been conducted in orbit which provide increasing knowledge for use on Earth.

But is it worth the resources spent?

As with any research effort, the wisdom of continuing the research is constantly brought into question. NASA scientists,

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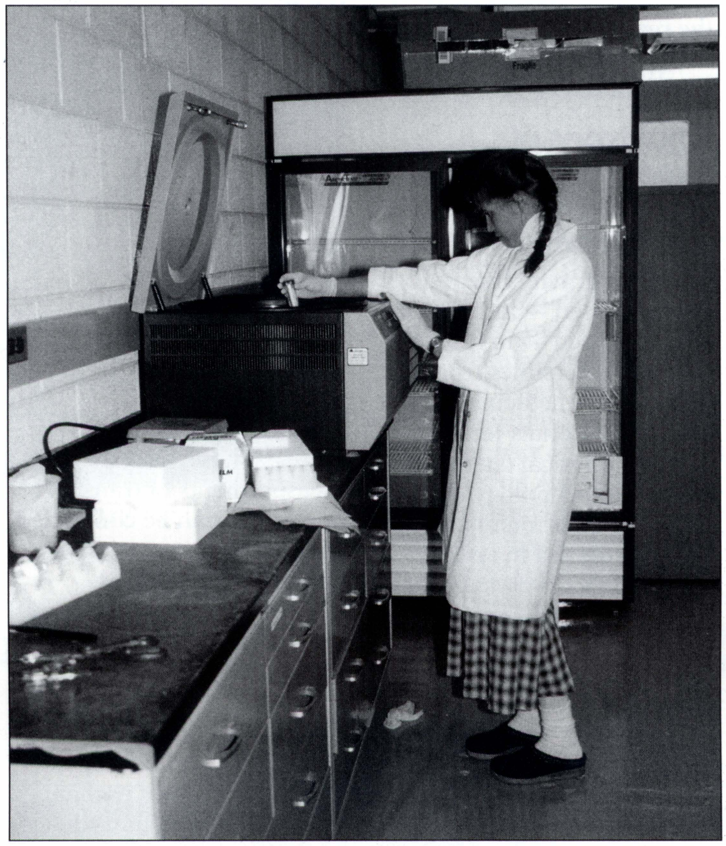
Right Ingredients Make Faculty Great Addition

BY STEFFANIE LISKEY

The newest member of the engineering faculty at Virginia Tech would like to be able to control living cells, and she may get the chance to do just that. With the help of chemical engineering principles, Kimberly Forsten, Ph.D., has been doing research focused on autocrine ligand binding and its unique characteristics. This research, the topic of her doctoral dissertation, could eventually have an effect on the methods available for treating diseases such as leukemia.

"Quantitative engineering analysis may guide biochemical researchers towards solutions, and into areas that might not have been intuitively obvious," Forsten said.

In laymen's terms, she is applying chemical engineering ideas at cellular levels. One should think of the cell, rather than a chemical, as a reactor in a chemical equation. In this way it should be possible to make predictions that would allow a chemical engineer to control cells, such as cancerous cells. More specifically, cells in the human body exist in groupings, for example, in muscle and organ tissues. Within the tissue, cells react through a series of coordinate reactions, and are influenced differently by outside influences. Forsten's research is aimed at figuring out how these different chemicals, or molecules, from outside of the cell influence the reactions within. To help illustrate this point, consider a football game. Team A being the uninfected cells, and Team B being the tumor cells, thus, the opponent. If Team A has the ball, they have a certain amount of options to execute which would put them closer to scoring. However, it does matter what option they choose because Team B still has a chance to intercept their attempts, and take over the game. In the case of Forsten's research, she would like to find a way to intercept the tumor cells' messages to the surrounding cells, and put them permanently out of action.


Dr. Forsten checks samples from the centrifuge.

Though her research is considered basic, the end result may be the design of new drugs or inhibitor models for future medical use and may possibly have importance in pharmaceutical methods. Her research definitely has strong impact in molecular biology and because of her work it has been shown that the autocrine system is more complex than realized. Doctoral Candidate Doug Lauffenburger, her advisor, feels that her research may possibly impact the medical profession by providing insights into how cells are regulated by biomolecular communication in tissue. This in turn will help scientists, doctors, and engineers learn what might have gone wrong to lead to pathology and how to design therapies to alleviate pathology. He was one of the first engineers to become interested in learning how cell functions are regulated by chemical and physical signals, applying a quantitative, engineering perspective to biology.

"Kim's project was an excellent example of a complicated system of cell regulation that needs engineering analysis to understand," he said,"Cell Engineering is an ideal field for applying the knowledge and principles chemical engineering students learn about reaction kinetics and molecular transport phenomena, to totally new situations of medical importance."

Forsten's research is a mix of both theoretical modeling work and experimental work in the laboratory. She feels it is important to have this equal balance when doing research in order to rationally design experiments in order to gain the desired data and interpret what is actually happening.

Forsten is in her first year on the faculty at Virginia Tech however, she is not new to the campus. She did her undergraduate work here in chemical engineering, then went on to the University of Pennsylvania for her masters degree. She received her docorate from the University of Illinois at Champagne. She increases the number of female faculty to 13, and joins Eva Marand, Ph.D, on

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The Great Egg Controversy

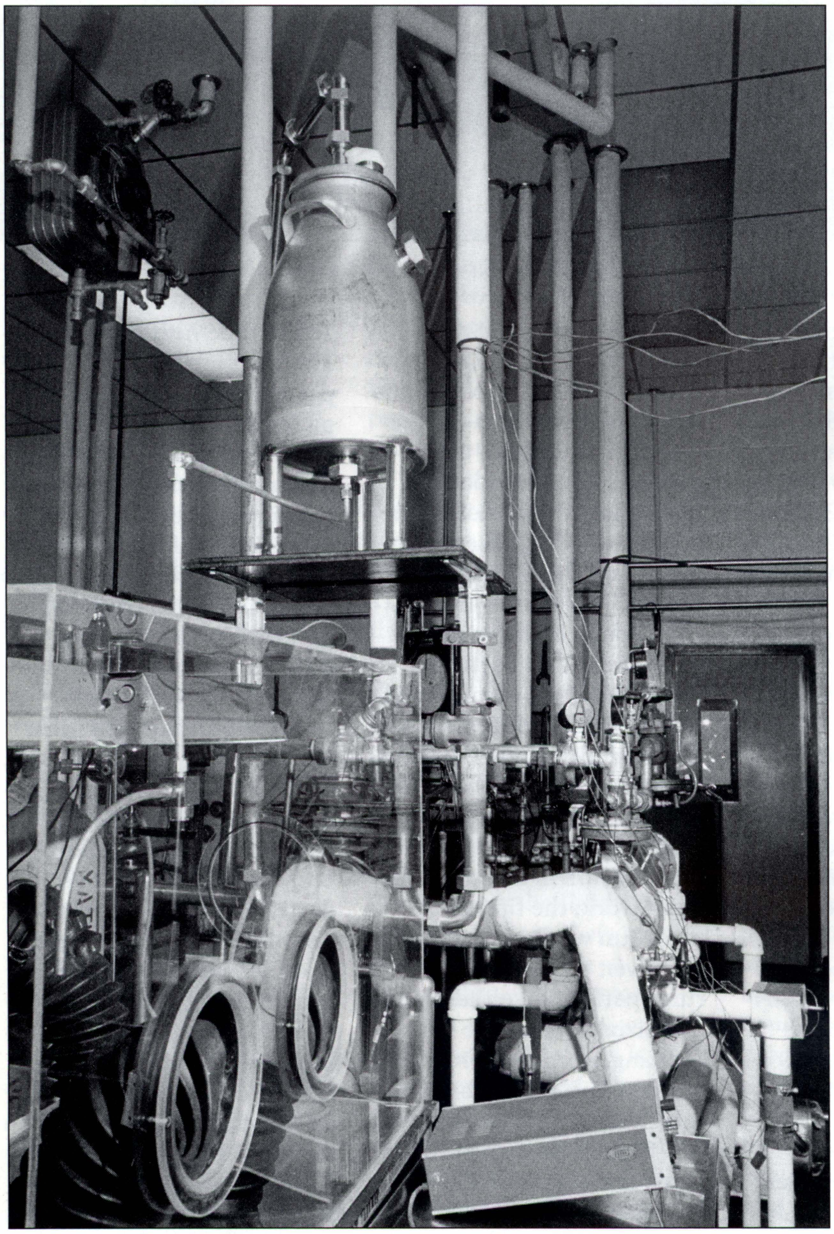
Consumers beware!!

While you might think all is well in the aisles of your local supermarket and bakeries, it is not. The eggs used in your beloved baked goods are in danger. They are at the center of a multi-million dollar battle raging silently in the egg industry.

BY SCOTT WALTERS

What may be quite surprising is that a small unnoticed project here at Virginia Tech is behind it all. The lawyers have returned to the birthplace of this legal fight in search of the truth. They have called upon a number of the original persons involved with the project to act as fact witnesses. One of these witnesses is Tech's own Dr. Peter R. Rony. He is the only member of the original project team remaining at Virginia Tech.

In late 1971, Professor Rony began his career at Virginia Tech. It was during these early years that this young, chemical engineering professor came to know Dr. Warren K. Stone. The elderly Stone was a member of the Food Science Department and specialized in the characteristics and processing of dairy products.


UHT DuPoint Teflon tube heat exchanger on right and aseptic packaging glove box on far left.

Between the years of 1973 and 1974, the two professors, with the help of an undergraduate chemical engineering student named Gary Criscione, researched a novel method of processing liquid foods. Traditional methods of pasteurization used stainless-steel, plate-and-frame heat exchangers. The only problem was the food particles would quickly stick to the stainless surface and corrupt the pasteurization process. Under FDA regulations the equipment needed to be constantly cleaned. Rony, based upon his experience with catalysis, came up with the idea of using Teflon® surfaces in the equipment.

The non-stick Teflon surface would not allow food to react, decompose, and then stick. This innovation would solve the traditional method's problem. They employed a Teflon tube heat exchanger donated to the Tech chemical engineering department by DuPont and began to conduct pasteurization experiments on fluid foods, starting with milk.

The first two experiments were unsuccessful. The processed food showed clear signs of bacterial contamination. Rony knew that the machine was working well. After considering the problem, he realized the food must be picking up bacterial contaminants from a non-sterile container or contact with the atmosphere.

The solution developed by Stone and Rony was to seal the entire system in a Plexiglas® glove box so the processed liquid food was packaged directly into a sterile container without ever coming in contact with the atmosphere. This sealed-system process is known as aseptic packaging and had already been used extensively in Europe for milk. Sterilization of the containers in an autoclave, or heat-sterilizer, prior to filling also became of prime importance. The glove box was sterilized with UV lights and an atmosphere of 10% ethylene oxide in carbon dioxide.

The improved process worked great. A patent disclosure to Virginia Tech was filed in 1974 and preliminary experiments were conducted up through 1977. All types of fluid foods were

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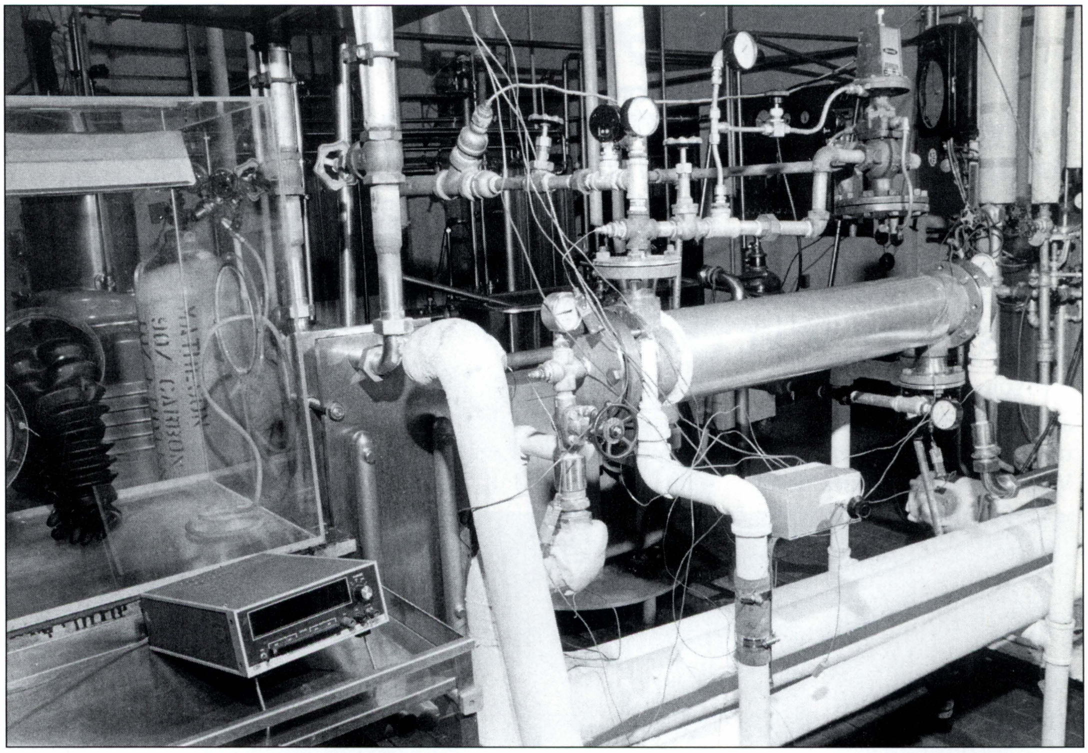
tested in the ultrahigh-temperature (UHT) pasteurization/aseptic packaging process. Dairy products and egg products comprised the primary test groups, but fruit juices were also tested. In 1977, one container of UHT-pasteurized, aseptically packaged whole eggs food lasted over a year in a refrigerated environment. It was also around this time that Dr. Stone decided to retire from the Food Science Department.

Professor Eskel Essary, also of the Food Science Department, picked up on the project after Stone retired. Essary specialized in the field of eggs. After he took over, the project concentrated exclusively on the pasteurization of eggs. The project also received a grant from the American Egg Board, allowing continued experimentation.



UHT heat exchanger and glove box, with liquid food storage tank located above.

Between 1980 and 1981, Rony and Essary performed more than 50 test runs with eggs. The results were successful. Essary used his influence to get the project publicity in egg industry magazines and newsletters. Even with all of this publicity, the use of the Teflon tube heat exchanger was kept a trade secret. Only the fact that aseptic packaging was being used was disclosed. When Essary retired in 1983 the experimental runs conducted in the Virginia Tech Food Science Department ended.

The publicity generated by Essary brought attention from the egg industry. An egg broker named Hugh Oldach became especially interested in the Tech process. His vision was to commercialize the process so that the industry would use it. Rony decided that since the project at Tech was over, it was time for Virginia Tech to give up the project. The inventors of the process agreed, and according to Rony, "the torch was passed to Oldach."

Oldach started working on the project in 1983. His first act was to find a place to continue development work on the project. North Carolina State University was a prime candidate. They had a commercial aseptic packaging machine called a Tetra Pak. Mr. Oldach wanted to connect the Teflon tube heat exchanger to the Tetra Pak machine, thus producing the desired UHT-pasteurization/aseptic packaging pilot-plant process.

N.C. State seemed willing and Professors Rony and Essary supported the selection. However, when N.C. State presented their draft legal agreement, they made no mention of the Teflon tube heat exchanger. They did not want to use it. Instead they wanted to use their own, traditional stainless-steel, plate-and-frame. Rony, Essary, and Oldach traveled to N.C. State in an attempt to change the decision. N.C. State would not budge, so negotiations ended. Rony regarded their actions as a "big disappointment, and that's putting it mildly!"

Oldach took the project to Quaker State Farms in Pennsylvania, a commercial firm which produced eggs and pasteurized them for commercial use by bakeries and other companies. Actual testing began in 1984. As often occurs in any development work, the first pilot plant run worked well. However, the next several runs, performed either in an oversized Teflon tube heat exchanger or an improperly cleaned Virginia Tech Teflon tube heat exchanger, did not.

Oldach fixed the problems, and succeeded in having a number of successful runs produced by the modified, oversized DuPont Teflon tube heat exchanger. The shelf life of UHT-pasteurized liquid eggs packaged in sterile containers in an aseptic chamber under ultraviolet light irradiation met targets for extended shelf life and low bacterial count. The next step was to interest a major egg processing company and transfer the process to commercial operation.

It was at this point that Hugh Oldach had difficulties. In the mid-1980s, major egg processing companies did not share Oldach's vision. They did not see the need for, or the advantages of, the Virginia Tech process based upon the novel Teflon tube heat exchanger. In 1985, Oldach ran out of money to support the project and the invention went into development limbo. Looking back on the affair Rony realizes that, "Oldach was a visionary, ahead of his time; the time just wasn't right."

Oldach's inability to

continue to financially support development of the Virginia Tech fluid eggs process was not the end of the story. It was, in fact, the beginning of a controversy that still confronts the egg industry.

In 1989, N.C. State stunned the industry with a patent, licensed to Michaels Foods, on a UHT-pasteurization/aseptic packaging liquid egg process. It was so surprising because prior information on the process, including the published works of Essary, Stone, and Rony, had been out for years. Milk products had also been processed this way in Europe since the 1970's. Many members of the egg industry realized there was no novelty in the North Carolina State patent. Because of this, many companies ignored the patent.

Michaels Foods launched infringement suits against two such companies: Pappetti Brothers of New Jersey and Bartow Foods of Florida. According to Rony, "A patent is only valid if it can stand up in court." Michaels Foods won the Florida case, which was not appealed because Bartow Foods immediately went bankrupt. A judgment against the Pappetti Brothers was issued by the judge in the case without trial. It appeared that the patent was holding up in court and would eventually be victorious. Two other lawsuits in Minnesota and California were still to be decided. Then, according to Rony, "Something very unusual occurred."

The original patent was a process patent, which meant that the UHT-pasteurization/aseptic packaging process was all that N.C. State attempted to patent. They did not apply for a product patent on the actual fluid eggs products. Many companies were getting around the patent by using slightly modified pasteurization processes and still producing the egg product. In legal discovery proceedings leading to the Florida trial, Rony, Essary, and the others were required to give legal depositions and also to produce confidential documents concerning their work. During the trial, the inventors of the N.C State patents were able to see these confidential documents. After viewing them, N.C. State and Michaels Foods decided to refile the original 1989 patent. This meant rewriting both the specifications and the claims so the patent would include both process and product claims.

"Oldach was a visionary, ahead of his time; the time just wasn't right."

Their goal was to obtain a process-and-product patent so companies would not be able to get around the patent. The problem with refiling is that everything is up for reconsideration by the U.S. Patent Office, even claims originally approved for the original patent. Thus, North Carolina State and Michaels Food took a risk with their refiling, and potentially stood either to gain a locking control over the fluid eggs industry, or lose their original patent and the new claims if the refiling was rejected.

Another unusual aspect of the refiling process is all documents passed to and from the patent examiner concerning the refiled patent application are made public, so interested parties can observe, and even comment on, the issues. For example, Professors Stone, Essary, and Rony, and Mr. Oldach all submitted to the U.S. Patent Office declarations in January 1995 on the refiling application by the North Carolina State inventors.

The question now is whether N.C. State's refiled patent will be accepted or rejected. If accepted N.C. State and Michaels Foods will gain control over a major part of the egg industry. Companies will be forced to pay royalties for producing UHT-pasteurization/ aseptic packed liquid eggs. If the patent is rejected, North Carolina State University and Michaels Foods stand to lose all their patent rights. The two trials in Minnesota and California have been postponed until the decision of the U.S. Patent office is made. For the time being the industry will have to wait and see what the future holds.

Looking back upon the events, Dr. Rony offers these final words of advice: "Engineering students should have learned at least three basic facts about patents from this experience involving Virginia Tech faculty: (1) The issuance of a patent does not mean that it will stand up to legal challenge in court, often in multiple States. It may, or it may not. (2) A refiled patent places the original patent, and all of its continuations, in jeopardy of being disallowed by the examiner who is acting on the refiled patent. However, the actions of the examiner are also subject to legal appeal and challenge. (3) The court challenges to an issued patent consume considerable amounts of time. The costs for either defending or challenging a patent in multiple States in the U.S. are high and require skilled lawyers. The patent better be valuable to be worth such costs." EF

Slick Thinking Takes Gar

BY MICHELLE ROMANOSKI

Of all the new materials on the market today, one has quietly made an important space for itself. It is used in clothing, computers and medicine, but since its inception in the 1960s, Gore-Tex has remained relatively unknown. Most people are proud to show you their Gore-Tex® lined boots, but have no idea what Gore-Tex really is.

Gore-Tex is expanded Polytetrafluoroethtlene (ePTFE), or expanded Teflon. Production of the material entails mechanically stretching the ePTFE, which results in a series of solid nodes of ePTFE with interconnecting small fibrils. The pore size, or fibril lengths, can be controlled in the manufacturing process. By determining the required size of the pores, the fabric can be made impervious to molecules of a certain size. For most Gore-Tex applications, a size that allows water vapor to pass freely while repelling water droplets has been chosen. Gore-Tex has applications in outdoor clothing because of its waterproofness and breathability, in computers because of its ability to optimize signal transmission and to ensure signal integrity, and in medicine because of its nonreactive nature.

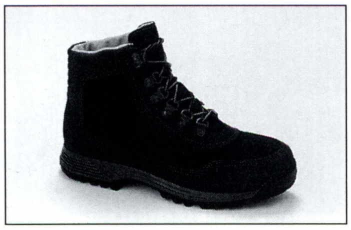
A commonly held misconception is that Gore-Tex is a DuPont product. Gore-Tex started out in the basement of Wilbert L. Gore. Gore, an employee of DuPont at the time, had continued experimenting with PTFE after his team had been disbanded. He first used the PTFE to coat computer wires, allowing them to be flexible but completely insulated. After this idea was ignored by DuPont, Gore went into business for himself. Wilbert Gore and his son Bob realized that if the PTFE could be unfolded, the resulting fabric would be porous to water vapor but not to liquid water.

Wilbert Gore started his company making only PTFE insulated computer wires.

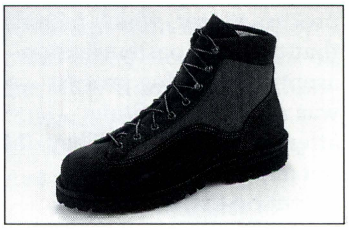
PTFE, commonly known as Teflon, was invented by Roy J. Plunkett for DuPont in 1938. Teflon is currently the most slippery substance on earth. This is because the hydrogen atoms in normal polyethylene are replaced by fluorine atoms in PTFE. These molecules are extremely nonreactive, causing the non-stick property of PTFE. Expanded PTFE retains its nonreactive properties, but as a fabric Gore-Tex becomes porous and "breathable." There are 9 billion pores per square inch in a piece of ePTFE. These pores are 20,000 times smaller than a droplet of water, but 700 times larger than a molecule of water vapor. These two properties allow Gore-Tex fabric to be used in a wide range of applications.

Gore-Tex has received its greatest attention for its use in outdoor equipment and clothing. W.L. Gore's first use of ePTFE was as tent fabric. Traditional tents become uncomfortable in wet weather because moisture becomes trapped inside the tent. Gore was interested to see if Gore-Tex would remain breathable in such an application, so a field test was made. The material remained totally waterproof in the first experiment until hail pelted through the fabric, creating holes much larger than a droplet of

Tempest Jacket (above) and Tempest Full-Zip Pants (right) are part of the product line that contain Gore-Tex of mont-bell america. Photos courtesy mont-bell America.



Danner Shoe Company was one of the first to use Gore-Tex in their waterproof boots. From bottom left to bottom right: Gemini, Danner Light II, Eagle IV and Sasquatch. Photos courtesy of Danner Shoe Manufacturing Company.



ment Industry By Storm

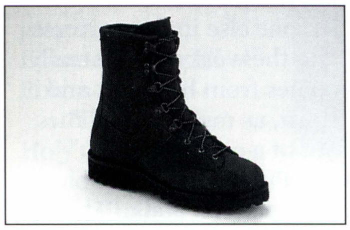
water. Another problem with the original Gore-Tex fabric was that the ePTFE was weakened by body oils, making it a poor candidate for waterproof clothing. The fabric in use today combines the original ePTFE with an oil-hating substance which keeps contaminents away from the fabric.

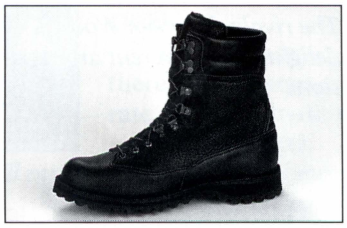
Gore-Tex proved to be too weak to be effective tent material. However, by incorporating the Gore-Tex membrane into the clothing layers of more rugged fabrics, Gore-Tex outerwear became the most durable waterproof, windproof, and breathable outdoor clothing on the market. The Gore-Tex membrane makes the clothing completely impervious to rain and snow. In terms of clothing comfort, breathability is the measure of the passage of moisture through the outerwear away from the body. This vapor transmission allows the natural cooling of the human body by evaporation of perspiration. Eventually all outerwear becomes saturated, halting the vapor transmission capabilities of the fabric. Gore-Tex takes much longer to reach this point than any other fabric currently on the market, and it dries out quickly. Gore-Tex fabrics are used in outerwear, footwear, and are also used specifically for several harsh environments. Gore-Tex is used in survival suits for military pilots who face the possibility of an overwater ejection. It is also used to protect chemical workers from splash accidents and on off-shore oil rigs for workers on exposed decks.

Wilbert Gore started his company making only PTFE insulated computer wires. Gore-Tex continues to be used in this field because the materials maintain clear signals with great reliability even in the most severe environments. Pathways constructed from Gore's materials are resistant to radiation and extreme temperatures while remaining remarkably lightweight. Another little-known application of Gore-Tex is its use in cleaning rooms for filtration and venting. Clean rooms are isolated rooms where the air is filtered to remove particulate matter and are used in microchip production and other instnces where dust is harmful to the product. The microporous nature of the material makes it ideal for the job. It is used for both air and liquid filtration and also to detect pollution and to filter contaminants.

One application that is not widely understood is the use of Gore-Tex in the medical field. PTFE is chemically inert, highly electronegative, and hydrophobic. Gore-Tex can also be autoclaved (heat-sterilized) and gas sterilized numerous times. This allows Gore-Tex to be implanted in the body without worry of rejection or infection making it an ideal medical product for implantation into the body. W. L. Gore and Associates currently markets vascular grafts, vascular patch material, soft tissue patches, peritoneal membrane substitute, and sutures through its Medical Products Division.

Gore-Tex is an extremely versatile material. Its variable porosity and nonreactivity make it useful in many technical applications. W.L. Gore and Associates applies for new patents continuously for new Gore-Tex products ranging from filters to clothing to implants. The porous microstructure of the expanded PTFE, the electronegativity, chemical inertness, and hydrophobic nature of the material allow the varied applications for which Gore-Tex is used.

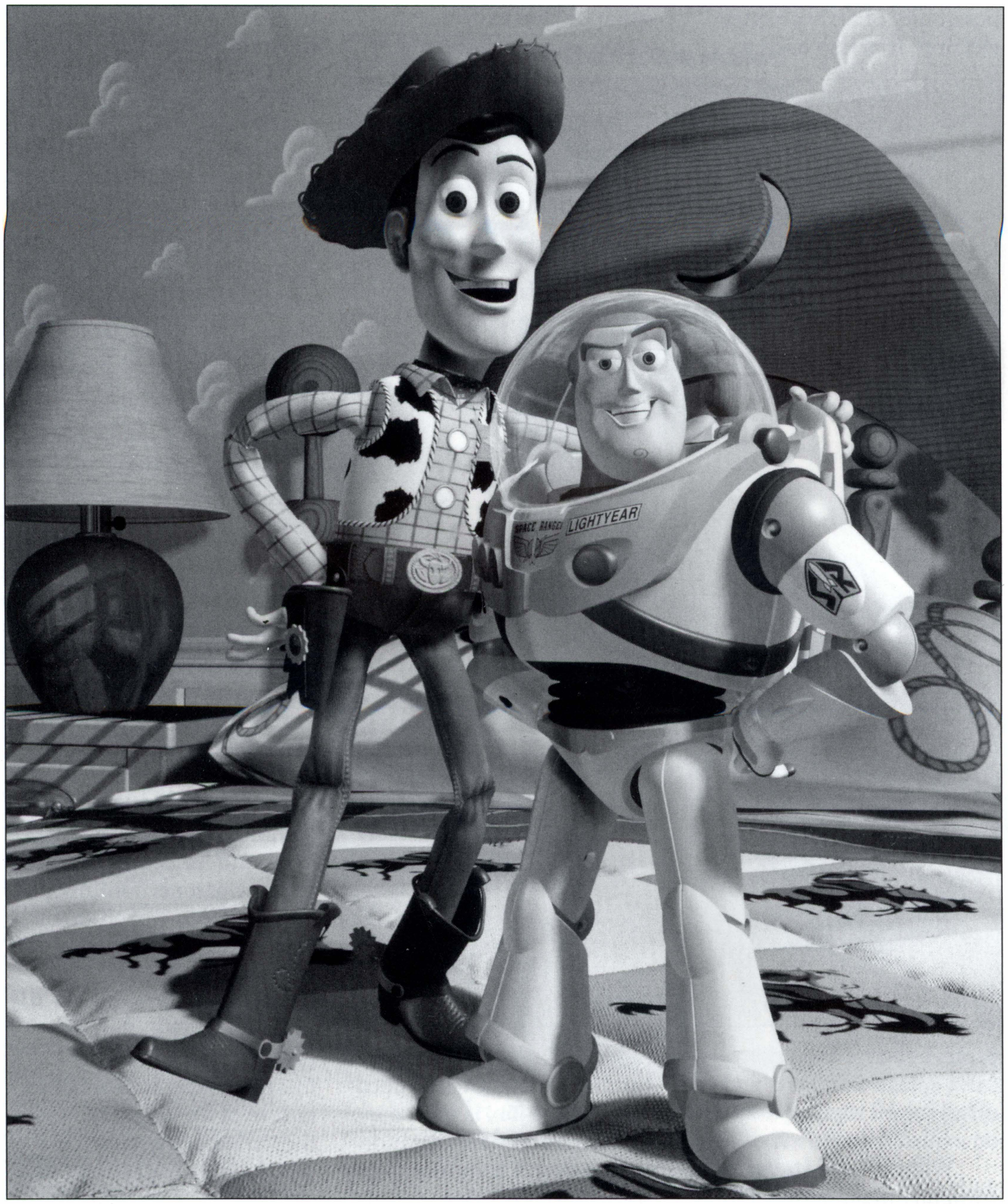




Virtually Impossible

The story behind 'Toy Story'

BY STEFFANIE LISKEY



The rivalry between Woody and Buzz leads to comic complications in Walt Disney Pictures' delightfully irreverent animated comedy-adventure, "Toy Story." Photo © Walt Disney Productions

It seems a contradiction of terms that something exists in virtual space. For anyone who has seen Disney's latest blockbuster hit "Toy Story," it's difficult to imagine that every creature, toy, prop, and setting does exactly that — exists entirely in virtual space.

In the first of a three-film deal between Walt Disney Pictures and Pixar Animation Studios, a Northern California-based pioneer in computer graphics, history has been made and the doors to the future of animation possibilities have been opened. Directed by John Lassater, this is one story that is making milestones.

"Working with John [Lasseter] and the folks at Pixar on this film was a delight from the first day," says Thomas Schumacher, executive vice president of Walt Disney Feature Animation and the studio's main contact on this project. "One of the key elements to making 'Toy Story' such a successful collaboration was constant contact and communication. The Disney-Pixar partnership was clearly a case of one plus one equaling three. John knows how to create warm and appealing characters through the medium of computer animation better than anyone else in the universe and the work you see really comes from his heart and spirit, as much as it comes out of a computer box."

Producer Ralph Guggenheim adds, "There's a certain degree of magic that occurred in Pixar and Disney coming together to make this film. Each group stretched beyond what they normally do to create something new and different."

In comparing the old to the new, "Jurassic Park," which used computer graphics to simulate some of its more terrifying actors, had six minutes of computer generated imagery. "Casper" has 40 minutes of CGI. "Toy Story" has, in its 1,561 total shots, 77 minutes of CGI produced by Pixar for the film.

In addition to the amount of CGI produced by Pixar's software, its high resolution is astounding. The resolution is typically 1536 x 922 pixels. In comparison to today's typical consumer monitors, that is about 2.25 times better. Characters have a dimension of reality and believability to them that suits the enormously creative story and amazes audiences.

Using a new generation of state-of-the-art software developed by Pixar and employing a team of top technical talents and artists specially trained for this form of animation, "Toy Story" combines technical artistry with a warm-hearted family story that is in the best Disney tradition.

Pixar's software was designed to be used by computer illiterate animators. In fact, the majority of animators on "Toy Story" had no computer training before working on this film.

The making of "Toy Story" is the end result of a 20-year dream for Lassater, as for all of Pixar's founders.

"This was the Holy Grail. Who would turn out the first computer-animated feature film?" recalls Guggenheim.

One of the earliest and most overwhelming tasks was the necessary expansion of Pixar's animation, editing, and post-production staff from 24 people to more than 100.

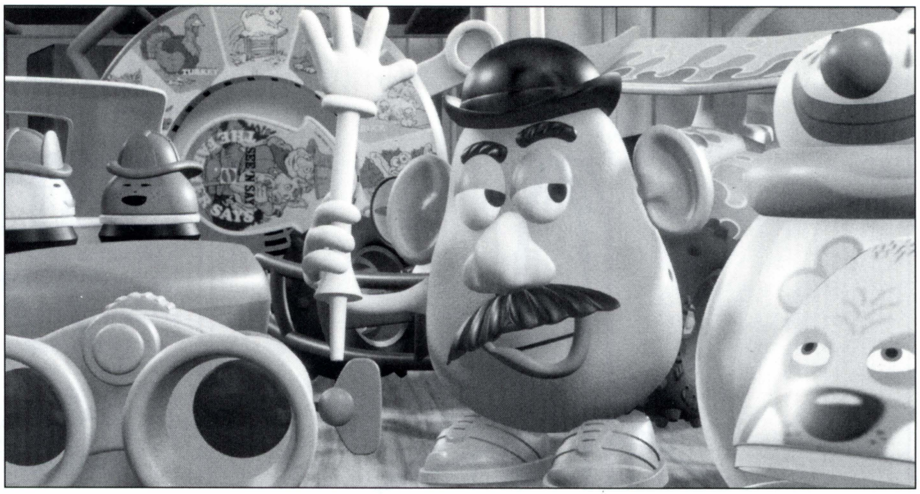


Photo © Walt Disney Productions

Hot-headed Mr. Potato Head provides two-sided humor throughout the entire movie. His light jokes and remarks hold a deeper meaning for older viewers.

"Definitely the hardest thing, logistically, was the staffing. In a live-action filmmaking, it's easy to find cinematographers, editors, art directors who traditionally have done this for a long time. Nobody has ever made a movie of this kind before. At times, I don't even think we understood the depth of that," says Bonnie Arnold, who joined Guggenheim as producer.

Technical Accomplishments:

Final frame count: 110,064 frames of computer animation

Final shot count: 1,561

Machine hours needed: Over 800,000 to render final elements

Maximum weekly output: 3.5 minutes of completed animation

The process of computer animation is similar to traditional animation. Yet, at the same time, it is quite different from tradition animation. Ten basic stages of production go into each image: storyboards, editorial, production design, modeling, layout, animation, shading, lighting, rendering, and film recording.

"It's like a giant animation factory," explains production supervisor Karen Robert Jackson. "Every frame must be approved in one stage before it can move down the pipeline to the next."

Similar to traditional animation, artists began with hand-drawn storyboards which were then cut into story reels. Once the reels are approved, they can go to the art department where overall lighting and color scheme for each sequence is determined.

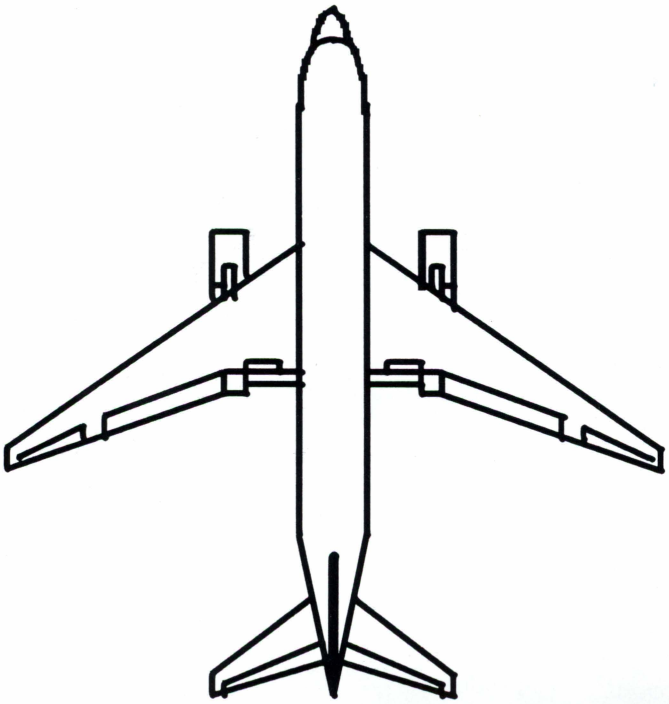
All animated objects and characters are modeled in three dimensions within the computer to create a complete 3-D description of their shape. In all, around 2,000 models had to be crafted for "Toy Story." Most character models have an underlying skeleton that allow fully articulated motion of joints and limbs.

"Modelers are like digital-age marionette makers. We create hundreds of interconnected strings that the animators can manipulate," explains animation scientist and modeler Eben Ostby.

For instance, there are 800 separate avars, animation controls, on Buzz. For some of the more

Continued on pg. 18

Panic spreads throughout the room as the toys watch Buzz accidentally fall out of the window. Photo © Walt Disney Productions.



Boeing 777:

Range: 4630 nautical miles
Speed (cruise): Mach 0.84
Length Overall: 209 ft, 1 in
Wing Span: 199 ft, 11 in
Take-off Weight: 535,000 lb
Accommodation: 375 Passengers
Upgraded versions planned with more than 550 passengers and approximately 7230 nautical mile range.

Now and Then:

The Boeing 777 and the de Havilland Comet

Designed to carry their companies into a new age of aviation, both the de Havilland Comet and the Boeing 777 were built in periods of declining military budgets and unsteady commercial markets. Both companies staked a significant portion of their future on the success of new technology aircraft — spending considerable effort to attempt to create a civil aviation standard. The Engineers' Forum *takes a brief look at these aircraft.*

BY AL LOWAS

What has more than 132,500 unique engineered parts, a total parts list of over 3 million, and set world speed records in September for Seattle to Geneva and for Frankfurt to Seattle? Answer: the Boeing 777.

Designed in an impressive five years with 10,000 people and a cost of more than $5 billion, the first Boeing 777 rollout was completed 29 months after the first order was received. It followed a four year market study to determine the potential of an aircraft sized between the 767-300 and the 747-400. To date, it has captured more than 75 percent of its intended market. Revenue service is expected to begin on June 7 with United Airlines.

The 777 also stands to be the most tested civil aviation aircraft in history, with more than 4,900 flights scheduled with a total flight time of more than 7,000 hours. It is one of the first planes to be designed almost entirely by computer and makes extensive use of high technology composites and assembly techniques. It has dual fly-by-wire controls, and its twin engines are the largest turbofans ever built.

However, much of the design goes beyond numbers and statistics. From the very start, the aircraft was designed with a "Working Together" philosophy. Boeing engineers were in constant contact with United Airlines and other customers around the world, with considerable attention being paid to these customers in making design decisions beyond just the drawing board. Each of the customers was consulted in order to ensure that the 777 met an entire range of needs. In fact, to introduce realistic testing of the aircraft, United Airlines flew 90 flights of the aircraft, simulating typical airline operations.

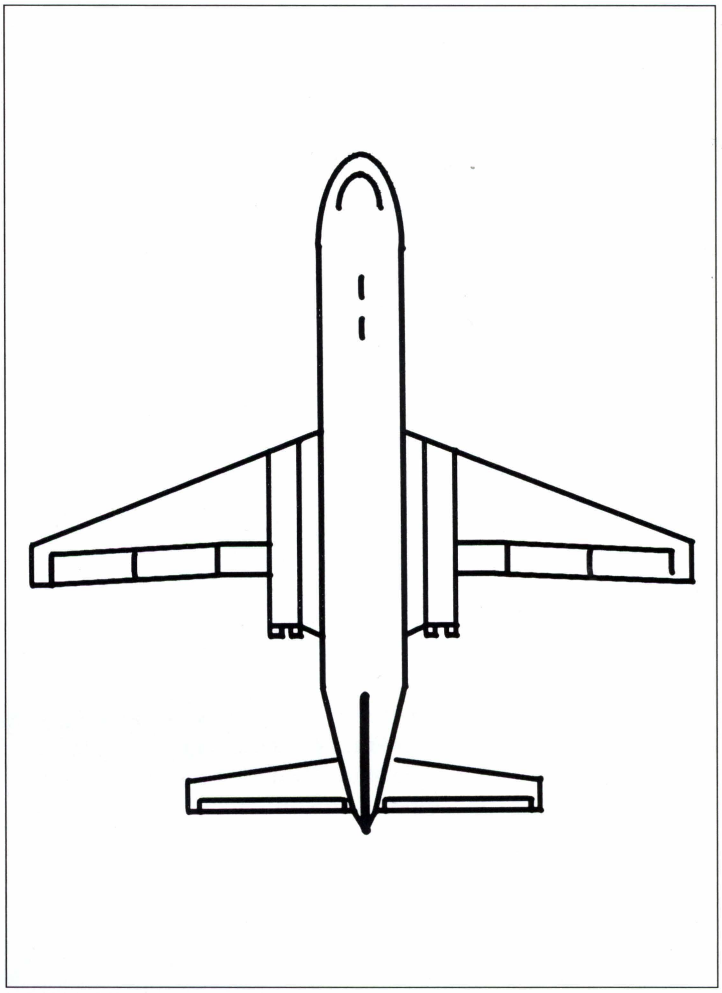
Typically, most subcontracting takes place within the country. On the 777, parts are made in countries ranging from Japan and Australia in the Pacific rim to Italy and Great Britain in Europe. While this allowed Boeing to obtain the best products possible, it also opened up cultural relations issues which had to be revisited with every redesign. According to Boeing officials, this was outweighed because foreign subcontracting also helps to make the aircraft easier to sell to foreign airlines. With customers already including Thai Airways, All Nippon Airways, Cathay Pacific Airways, and Lauda Air, this was an important consideration.

Within Boeing, design and build groups worked side by side in Product Definition Teams, developing the engineering and the tooling simultaneously, as opposed to sequentially as is usually done in the aircraft industry. New procedures initiated from the floor took a fraction of the time typically needed to implement. In the primary assembly area, the largest four hook crane in the world was developed to complete the final assembly of an aircraft uniquely designed to standards set by the assembly personnel who would use them. Beyond the goal of reducing which any aircraft has, the 777 was designed to be easy to buildso it could be delivered to the customer as quickly as possible.

This is not to say the design proceeded without problems. In spite of the newly opened communication channels, cases did arise where more than one part was designed to be assembled on the same spot on the aircraft, which necessitated quick redesigns. The rudder, crucial for a twin-engined aircraft such as this, underwent numerous redesigns, some quite late in the program. Additionally, many of the lightweight aluminum lithium components had to be redesigned with another material after small cracks caused by the manufacturing process were found in the components.

All of these have been solved, however, and Boeing is moving on to create its next version in the intended 777 family: the 777-300. Designed with a 33-foot stretch to accommodate more passengers, the overall configuration for this aircraft was completed in October. Boeing expects its new design methods to yield a 30 percent lower development cost than industry standards, and already has orders for the model.

Learning from previous aircraft experience and looking ahead to the future of the aviation industry, Boeing and its customers expect the 777 family to bridge the way into the 21st century — and to be the industry standard for Extended Twin Operations aircraft for years to come. **EF**



de Havilland Comet:

Range: 2,910 nautical miles
Speed (cruise): Mach 0.6
Length Overall: 118 ft
Wing Span: 107 ft, 10 in
Take-off Weight: 162,000 lb
Accommodation: 119 Passengers

The de Havilland Comet, in spite of its technical achievements, did not fair very well. Due to poor structural design the aircraft did not survive pressurization as it should have. The aircraft was designed to bring the company to the forefront of aviation, these failures eventually caused the demise of de Havilland (now a subsidiary of Boeing). On the following pages is a reprint of coverage of these issues, which first appeared in the Virginia Tech Engineer *40 years ago.*

The Exploding Comets

By K.H. Digges

On the morning of January 10, 1954, the swift, sleek BOAC comet G-ALYP was climbing steadily through the cold air high above the Tyrrhenian sea, just off Elba.

Forward, the crew was finishing the last of its routine duties of the ascent. The pilot answered routine duties of the ascent. The pilot answered another BOAC scheduled flight; the Agonaut-G-ALHJ wanted to know the height of the cloud tops. He spoke briefly with the Argonaut's captain; hearing no acknowledgment, he called back.

"GHJ from GYP," he said, "Did you get my..." With an explosive roar the Comet suddenly disintegrated. Human bodies and shattered pieces of burning metal plunged down into the Roman's sea.

The comet fleet was immediately grounded and the planes were rechecked for structural weaknesses. The best guess from the investigation was that the accident of G-ALYP resulted from the new pressure re-fueling system developed for Comets. Corrections were made, and the fleet was again released for operations on March 23.

Only sixteen days later, a second Comet-G-ALYY was mysteriously lost near Naples under almost identical circumstances. Both planes were less than an hour out of Ciampino Airport at Rome, both climbing for altitude. Neither reported any sort of trouble. Both disappeared with all passengers, leaving little trace.

Again the Comet fleet was grounded, and frantic investigations to find the cause of the strange Comet disasters were begun by de Havilland, BOAC, and RAE. The investigation, led by Sir Arnold Hall at Royal Aircraft Establishment, Farnsborough, is perhaps the most remarkable piece of scientific detective work which has been done in Britain since the time of Sir A. Conan Doyle's Sherlock Holmes.

The story of this investigation has been adopted from an article by David A. Anderson, Engineering Editor, of **Aviation Week**.

There are two methods of conducting an investigation of this kind. First, the wreckage is examined to deduce what might have happened. Second, an undamaged airplane is examined and tested to deduce what could happen.

The Search for Wreckage

The use of the first method seemed to be almost hopeless; both the Elba and the Naples disasters had occurred high above water, and the wreckages lay scattered on the bottom of the sea. The water off Naples was hopelessly deep, and the location of the wreck was uncertain. Off Elba, the pieces rested 600 feet down, somewhere near a known minefield, still unswept and unsweepable.

In spite of theses difficulties, a search for the wreck off Naples was undertaken. First, the sea bottom was searched with sonar. In places where favorable echoes were received, further investigation was performed by divers or underwater television. After nearly a months' search, the first piece of wreckage was trawled out of the deep, and the long recovery period began in earnest.

There are three phases of the study of wreckage:

- **Reconstruct the wreckage.** This shows each part in relation to the whole assembly and shows discontinuities in the damage. By these clues, the investigator can say whether the plane was on fire when it broke up or afterward; whether damage was caused by the initial accident or by impact with the ground or water.
- **Determine the kinds of major failures.** Metal failures, like criminals, have characteristics as individualistic as fingerprints. Fracture analysis lets the technician decide that this joint failed in tension, this in shear, this in torsion, and these in fatigue.
- **Determine the sequence of the failures.** This is the crux of the whole study, and depends on the recognition of the footprints of motion as one part moves over another in break-up.

Underwater

At the same time, tests were being conducted on undamaged Comets. In order to test for fatigue of the pressure cabin, an underwater test was arranged. Comet G-ALYU was obtained from BOAC to be tested for destruction.

G-ALYU was stripped down of all accessories that could be water-damaged. All non-structural fittings were removed for better inspection of the skin and structure. The vertical and horizontal tails were taken off, and the Comet was wheeled into its final flights — made under water.

The tank was completed around the plane, with air-inflatable seals over the wings. The tank and the Comet were filled with water, and pressure was applied inside the fuselage.

Outside the tank, hydraulic pistons lifted the airplane to simulate the equilibrium of level flight, then fed in fluctuating loads representing gusts during average flight. Cycling rate was fast, and a complete flight took only five or six minutes. The data for the gust rate came from records of the earlier flight tests in a BOAC Comet, when counting accelerometers were used.

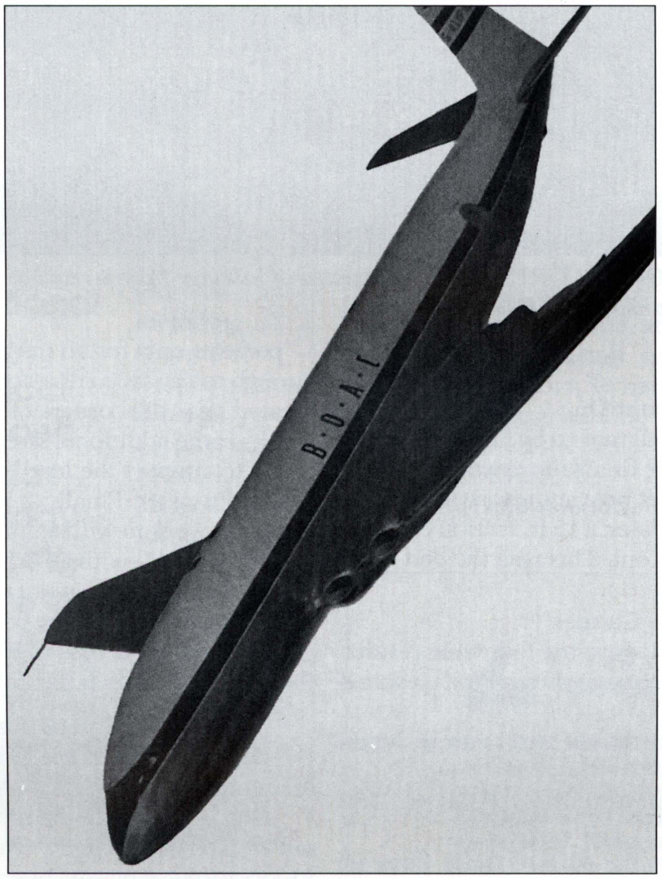
• **In the Air** — A third phase of the Comet investigation was proceeding at a feverish pace. BOAC Comet G-ALAV was instrumented for flight test in record time. The aim: investigate flutter and vibration "as near to the tiger" as possible.

Loaded with more than 100 specialized flight instruments and chased by a Canberra, the Comet was to be flown to 40,000 ft. unpressurized for 15-min. tests. Duration of the tests was set by the physical limits of the crew, operating as they did on oxygen only, at an extreme altitude.

• **And Still Other Tests** — Backing up the major phases of the investigation were a host of other special tests, made with ingenious models or apparatus. In general, they were done to prove a point deduced from examination of wreckage or from theoretical considerations.

One example: Medical evidence of Prof. Antonio Fornari, an Italian specialist who performed post-mortem examinations on 14 of the 15 recovered bodies, indicated the passengers all died in the same way. They had been thrown violently upward and forward, fracturing skulls and thoraxes; their lungs had burst, showing evidence of explosive decompression. How could the violent motion of the passengers be demonstrated.

It was done finally with 0.1-scale dynamically similar transparent models of the pressurized cabin, complete with scaled-down chairs and dummies. The model was pressurized in an evacuated tank and ruptured. In the complete disorder that followed, passengers, chairs and cabin wreckage blasted out of the hole in the roof. Study of highspeed camera frames showed the motion to be exactly the kind necessary to produce the injuries Fornari found.



The "COMET"

Another example: Skin burns were found on some of the bodies. Did they occur before or after death?

Dr. R.D. Teare, assistant pathologist at St. George's Hospital and member of the Royal College of Physicians, wondered about this point. In checking over Formari's report, he was in complete agreement with the observations and deductions. But the question could not be ruled out.

Teare made some tests with human skin, covering it with clothing and setting it in water with burning kerosene on the surface. The recovered skin was burned, even though the cloth was unhurt. The burns must have occurred after death.

• **Fire and Ashes** — Pieces of the wreckage showed that they had been burning for considerable time before being extinguished by the sea. How long had they been afire?

Duplicate structures were built and burned in intense fires corresponding to those following aircraft accidents. A wing spar section took about three minutes to burn through to the point of resemblance to the wreckage. Therefore, reasoned the Farnsborough staff, the wreckage had been falling for about three minutes after it broke up and caught fire in the air.

Next question: Where was it when it broke up and how did it break up so that the fall took so much time.

Again, they resorted to dynamically similar models. Dozens of them, built to 1/36th the scale of the Comet, were made to come apart in the air in sequence. They were designed with major assemblies fastened together with loose pins. To each pin was attached a string of varying length.

The engineers took the models of the roof of one of the Farnsborough hangars and catapulted them into flight. The strings, attached to a pin at the launching point, pulled the model apart in a predetermined sequence.

The wreckage pattern on the ground was compared with the position of the pieces recovered from the sea until good agreement was obtained.

Other similar models were dropped at altitude and broken up the same way. Timing the fall, and working backwards with the laws of dynamic similarity, the engineers deducted the Comets were at about 35,000 feet, or just at the top of their climb when the accidents occurred.

The Case Breaks

As the investigation dragged into the summer, a great deal had been learned about the accident, yet the cause was still a mystery. The break finally occurred in June when scientist Hall noticed several lateral scratches and marks along the port wing, extending almost to the ailerons. Something had impacted on the wing and had been forced or dragged sidewards. It must have been moved by a considerable force to stay on the wing for such a great distance in the high speed slipstream over the wing.

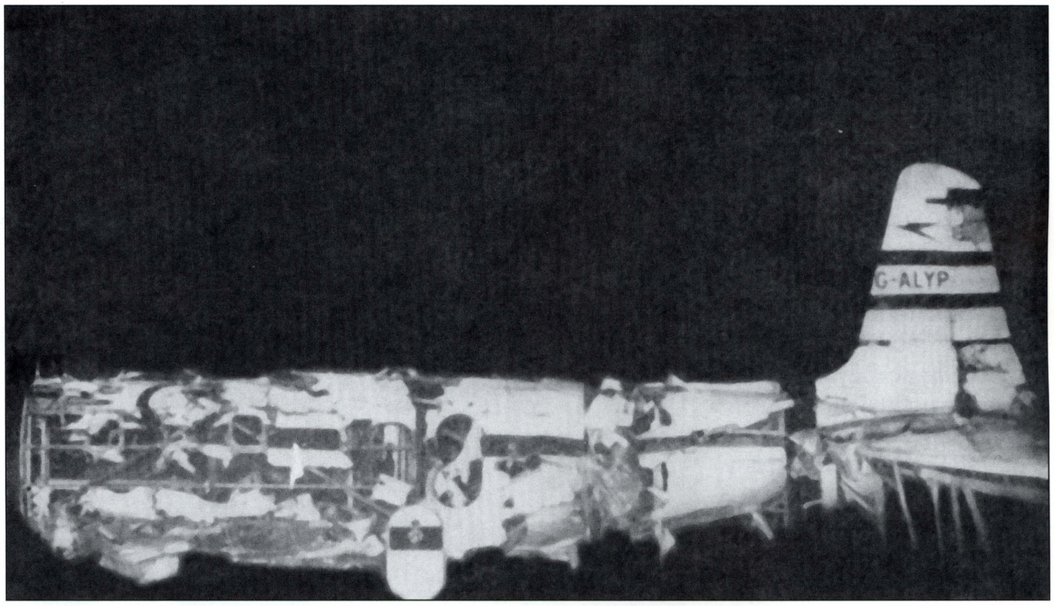
On June 21, a piece of the port cabin was recovered. Its jagged edge matched the scratches in the wing. It had been hurled across the wing by a tremendous explosive force before the Comet disintegrated. This, inferred the RAE scientists, was the first piece to fail.

A few days later, the fuselage of the submerged test Comet-G-ALYU blasted open, starting from a fatigue crack at a rivet hole near a corner of an escape hatch.

Tank Tests

Comet-G-ALYU had made 1,231 pressurized flights in BOAC service, and had 1,600 simulated flights underwater before pressurization leaks began to show. But the cabin integrity still held.

Then without advance warning, the fuselage failed. An eight-by-three hunk of structure ripped out of the rear fuselage. This failure, attributed to fatigue beginning at a rivet hole, was repaired with a new panel. Some skin cracks around other windows were patched with external plates riveted to the skin, and strain gauges were installed in positions at window corners



COMET CORPSE is reconstructed of fuselage from wreckage after disaster to world's first jet transport off Elba.

The Test Went On

At 3,833 cycles the wing was damaged by fatigue and had to be repaired. At 4,255 cycles, the final failure was spotted as a 1 in. crack extending from a rivet hole at the forward corner of the No. 7 window. Sixty cycles later, a 15 ft. section containing windows 7 and 8 was blown out. This was the end of G-ALYU.

Results From Gauges

The strain gauges on G-ALYU gave the following results:

• **Cabin differential pressure** gave a stress which reached 43,000 psi.

• **Difference between flight loads and ground loads** gave a stress additive of 650 psi.

• **Gust loadings** produced an additional stress of 1,950 psi.

• **Total maximum stress** is the sum of those three or 45,700 psi. This figure represents about 70% of the ultimate stress of D T D 546, the aluminum alloy forming most of the Comet.

But there were other stresses which the strain gages did not show.

Effect of Variable Stresses

Only when variable stresses due to wing flexure, gust loading, cabin pressure fluctuation, engine vibrations, and temperature variation, simultaneously reached their maximum value is the total stress at a maximum value. This point is probably reached not more than 2 or 3 times per flight.

In the case of the Comet, this total stress may have been not more than 70% of the ultimate which the weakest section could withstand before failing. However, window corners and rivet holes are both stress raisers. That is, holes and corners are surrounded by stress concentrations too localized to be picked up by strain gauges. This stress concentration added to the constant and maximum variable stress was believed to be sufficient to exceed the ultimate of the Comet structure. Thus, at intervals, the metal's ultimate strength was exceeded — perhaps only for an instant. Yet, this excessive stress was enough to cause small cracks to form around the rivet holes located near the corners of windows. With the formation of cracks came additional stress concentrations and less actual metal to support the load. The cracks grew and the section became weaker. Finally, a section around the windows became too weak to withstand the internal pressure of the pressurized cabin — with an explosive force, the section blew out like the cork out of a giant champagne bottle.

The piece of fuselage which left scratches along the wing as it was blown across the 500 m.p.h. slipstream illustrated the force with which the failure occurred.

Failure Sequence

Now it was possible to reconstruct the last moments of life remaining to G-ALYP high over the Roman's sea.

She was nearing the top of her climb on a routine flight out of Rome. Suddenly, with the roar of a blockbuster, G-ALYP's fuselage blasted open. First a large portion forward of the cabin blew out, then the major portion of the cabin roof.

Within three-tenths of a second, the cabin was cleared of everything movable. Seats, luggage, passengers were catapulted up and forward in a tangled mess. Death was instantaneous.

Still plunging forward under its tremendous inertia, G-ALYP swung to a near-vertical attitude. Wings and fuselage failed under the sudden, enormous air loads. The nose and tail of the fuselage separated; the wing broke into three pieces. the center section, now burning fiercely, snapped to an inverted position and slowly spiraled down through the thousands of feet to the water.

Before it, the fuselage nose and tail raced, open-end toward the water. They splashed; then the wing slapped the surface and sank. Nearby, two wingtips fluttered down, catching the mid-morning light on their polished surfaces.

This was the havoc caused by an overstressed rivethole.

THE END

Continued from page 4

the chemical engineering faculty. The total number of faculty in the College of Engineering is now 275, women accounting for fewer than five percent.

Although many no longer perceive engineering to be only a man's field, women are still few and far between in the field. Thus, Forsten said she feels fortunate that, being aware of the possible obstacles, she has not actually encountered any in her education. At Tech, she recalls that a high proportion of very intelligent women were in chemical engineering, not only being there, but leading in the class. Lauffenburger comments that if ever an obstacle were placed in Forsten's way she would overcome it "by thinking hard, working hard, trying different approaches, and not giving up."

"Her research has been published in an unusually wide range of journals, including Journal of Computational Biology, Biophysical Journal, and Molecular Immunology ...that's pretty impressive for an engineer!"

As a member of the faculty, Forsten finds her colleagues very supportive and feels very fortunate that she is one of two women in the department.

"It's refreshing to have another woman faculty member in Chemical Engineering. I hope I can help her be successful here," Marand said.

Lauffenburger, a Ph.D. in chemical engineering, is an avid fan of Forsten, as well as co-author of eleven of fifteen research papers and presentations Forsten has done. He describes her as "energetic, determined, very smart, hard-working, and enthusiastic," and says, "she is one of my very best students and one of my favorite people."

Lauffenburger also seems very impressed by what she has accomplished with her research so far, as he well should be. He comments, "Her research has been published in an unusually wide range of journals, including Journal of Computational Biology, Biophysical Journal, and Molecular Immunology... that's pretty impressive for an engineer!" Lauffenburger is currently on the faculty at Massachusetts Institute of Technology. He is professor of chemical engineering and of health sciences & technology, and director of the Center for Biomedical Engineering.

Forsten arrived on campus in August and has since then been settling in to her office in Randolph Hall. She is not teaching any classes this semester, but will be teaching a course for juniors in the spring titled Chemical Process Modeling. She is hopeful that in October at least one graduate student will share her research interest and select her as his or her advisor. If so, Forsten will have company in her lab in Randolph in the future. Forsten also hopes to involve interested undergraduates in her research next semester, giving them the opportunity to learn proper techniques, think through a presented problem, obtain data and analyze results. As an undergraduate at Tech she had the opportunity to do research with Dr. Hanson in Chemistry, and found it to be a valuable experience.

"The valuable interactions with Dr. Hanson and his graduate students convinced me that while success may not follow all experiments, the pursuit of new information and knowledge could be both exciting and rewarding," she said.

Forsten has enjoyed a successful career to date, and has won many academic and professional honors. To name just a few of these honors, she has received the Shell Fellowship Award, the University Fellowship Award from University of Pennsylvania, and the Diamond State Scholar Award from the state of Delaware. She was the recipient of a Marshall Hahn Scholarship as an undergraduate at Tech, the 3M Scholarship, and the Allied-Signal, Inc. Scholarship. Dr. Forsten is also a member of Omicron Delta Kappa and the American Institute of Chemical Engineers. In addition to all of these honors, Dr. Forsten still finds time to be an athlete and competitor. She is the National Women's Director of the Ultimate Players Association (UPA) which is the governing body for ultimate frisbee play in the United States. With all the ingredients for success at her fingertips, it appears that Kimberly Forsten is going to enjoy a prosperous career for a long time to come. EF

Toy Story

Continued from page 11

organic characters, anything involving skin, clay sculptures were built and then digitally scanned into the computer.

In rendering the images used to make the movie, the total storage required for all the frames you actually see in the movie is 500 gigabytes. And the total storage required for all film information is 1 terabyte. Compare those numbers to the averages for a computer bought today. A new Pentium model has an average of one gigabyte of storage, and to buy more storage space it costs approximately $100 for one megabyte.

Located in Point Richmond, California, Pixar has grown from its origins as the Computer Division of Lucasfilm, Ltd, into a company of over 150 employees. Over the past few years, software products from Pixar have become available commercially and are the new industry standard. The best known is RenderMan®, which has created realistic effects in a number of award-winning motion picture and television studio productions. This software package has allowed design studios to create visual effects in movies such as "The Abyss," "Terminator 2: Judgement Day," and "Jurassic Park."

The future of animation and movie effects has been geared towards "infinity and beyond" and Pixar is leading the way.

"One of the great things about computer animation, is that every step of the way you see something new," Lassater said. "I feel lucky to be able to come to work every day and look at things and say 'Oh my, look at that. That's amazing.'" EF

Continued from page 3

and many others from around the world, have only to note the successes of their ventures to prove that space research benefits society.

However, many others believe this benefit is far overshadowed by the costs and the inability to utilize many of the technologies developed. While history will write a less subjective cost-benefit analysis than can be written today, it is easy to see the validity of the question.

Current space technology is such that only a very small capability exists for actual production of desired products in orbit. The Russians, for example, have been able to successfully manufacture and sell a shoe-boxed size container of crystals grown in space. However, the quality of these crystals was not as good as it could have been, primarily due to the higher cost of launching better equipment into orbit. Also, the actual cost of the crystals was well beyond the price of most consumers. Many claim that a practical high-use space transportation system must be in place before space-developed materials can be of any real use on earth.

What the future will bring for microgravity research depends as much on current public demand as it does on the chance that always surrounds new technology development. If the past two decades are any indication however, it is certain that microgravity research in space will continue to yield technological insights and benefits to mankind here on Earth. *EF*

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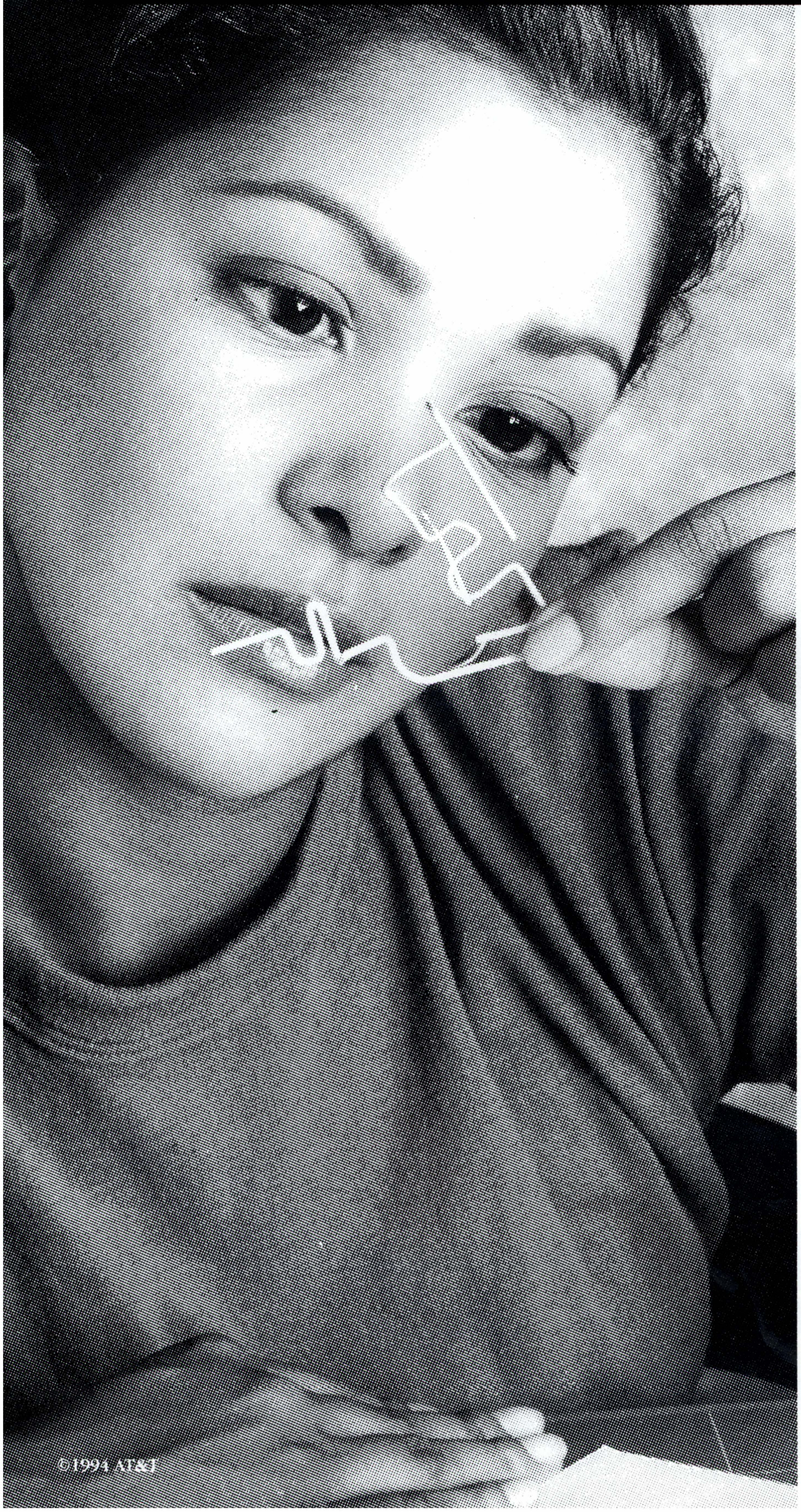

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