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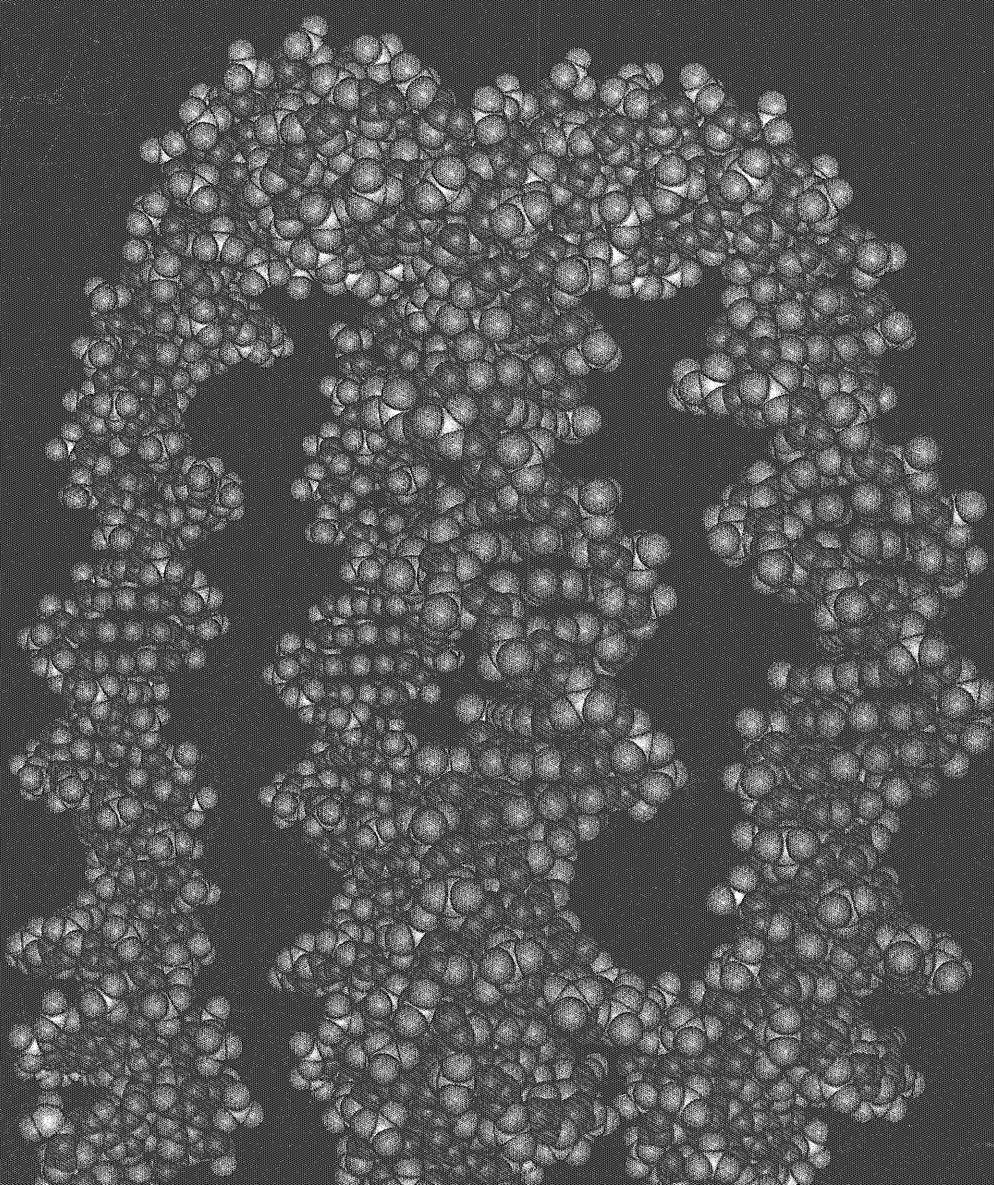

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IT: Keeping Up With the Times

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Can Mortal Man See Higher Dimensions?

FALL 1, 1983

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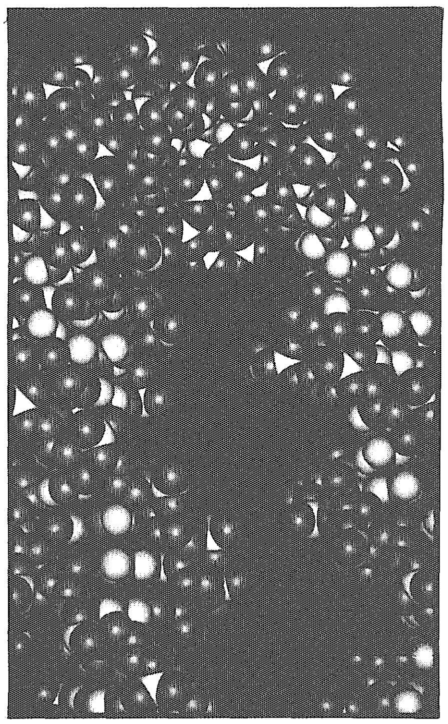

The cover shows a computer simulation of a DNA molecule, courtesy of Livermore Laboratories, University of California, Berkeley. Note how the atoms have varying sizes and are shaded to give the impression of depth. More powerful computer techniques are now being used to help certain mathematicians visualize the fourth and fifth dimensions.

Features:

Departments:

Log Staff:

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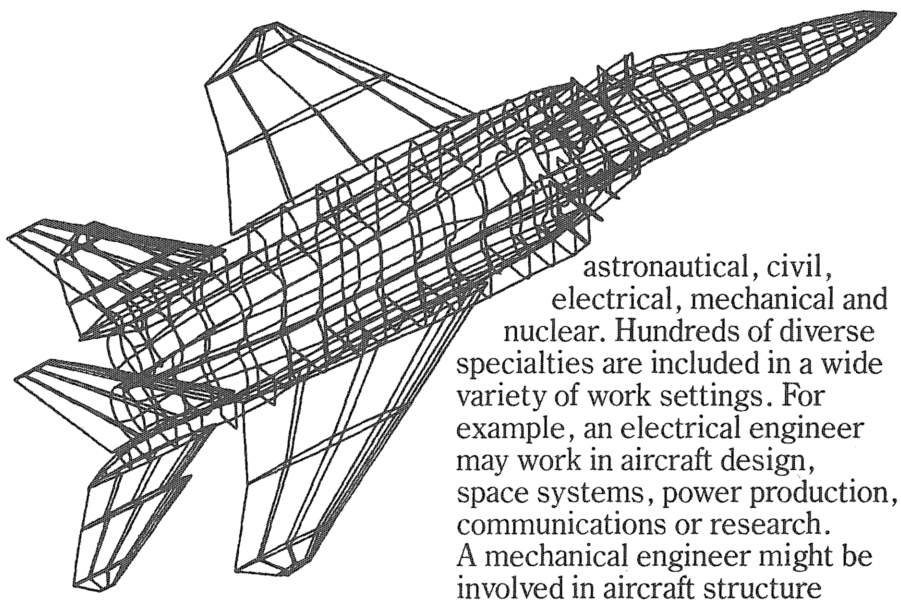
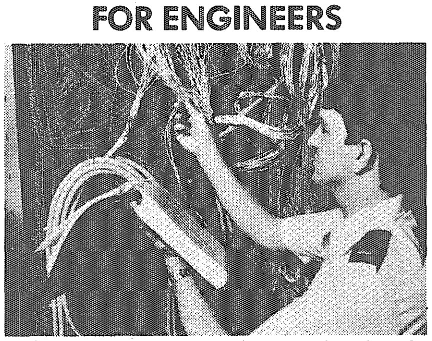
ENGINEERING TAKES ON EXCITING NEW DIMENSIONS IN THE AIR FORCE.



Computer-generated design for investigating structural strengths and weaknesses.

Developing and managing Air Force engineering projects could be the most important, exciting challenge of your life. The projects extend to virtually every engineering frontier.

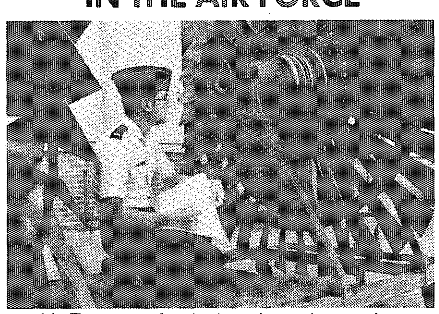
8 CAREER FIELDS FOR ENGINEERS



Air Force electrical engineer studying aircraft electrical power supply system.

Engineering opportunities in the Air Force include these eight career areas: aeronautical, aerospace, architectural, astronautical, civil, electrical, mechanical and nuclear. Hundreds of diverse specialties are included in a wide variety of work settings. For example, an electrical engineer may work in aircraft design, space systems, power production, communications or research. A mechanical engineer might be involved in aircraft structure design, space vehicle launch pad construction, or research.

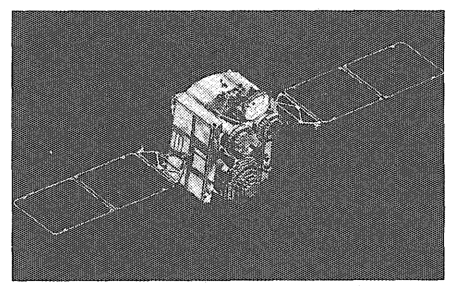
PROJECT RESPONSIBILITY COMES EARLY IN THE AIR FORCE



Air Force mechanical engineer inspecting aircraft jet engine turbine.

Most Air Force engineers have complete project responsibility early in their careers. For example, a first lieutenant directed work on a new airborne electronic system to pinpoint radiating targets. Another engineer tested the jet engines for advanced tanker and cargo aircraft.

OPPORTUNITIES IN THE NEW USAF SPACE COMMAND



Artist's concept of the DSCS III Defense Satellite Communications System satellite. (USAF photo.)

Recently, the Air Force formed a new Space Command. Its role is to pull together space operations and research and development efforts, focusing on the unique technological needs of space systems. This can be your opportunity to join the team that develops superior space systems as the Air Force moves into the twenty-first century.

To learn more about how you can be part of the team, see your Air Force recruiter or call our Engineer Hotline toll free 1-800-531-5826 (in Texas call 1-800-292-5366). There's no obligation.

AIM HIGH AIR FORCE

Editor's Log

Once again it's that time of year when the nights become cool, the wind turns crisp and the young engineer's mind turns to his calculator. In short, summer is over, and school has begun once again.

Minnesota Technolog welcomes you to the Institute of Technology. We returning students can once again experience the intellectual stimulation that comes from exploring new fields of knowledge, the sublime satisfaction of forcing the walls of ignorance aside as the horizons of the mind are pushed outward, the euphoric thrill of striving toward the peak of academic excellence . . . well, anyway, it's nice to see the old friends again. And for you freshmen, some advice that should prove useful: *Always remember that even though a line is the shortest distance between two points, here at the University the shortest line is not always the fastest.*

Although at first glance it appears that the passing summer has left I.T. unchanged, there are several differences between this year and previous years. The new Civil and Mineral Engineering building has been completed and is being used. The halls of I.T. are now under the watchful eyes of a new dean. Also, as last year's graduates will sadly tell you, engineers and scientists can no longer pick the job they want from a selection of four or five offers. Engineers and scientists have always been extremely susceptible to economic maladies; the last recession has proved to be no exception. So how does a student ensure himself that four or five years of waiting in the registration line will lead to more than a wait in the unemployment line? Sure, hit the books, study hard. But unemployed graduates with high GPAs have become all too common. What today's graduate needs is something which will make him or her unique, something that will help him or her stand out amidst the collage of faces an interviewer sees each day.

The answer is to get involved. Join an organization, take part in an activity, contribute to a project. The University abounds with organizations in need of student participation. Give these some of your spare time, and they will in turn give you that extra push in the job market race.

The Bigger the Summer Vacation, the Harder the Fall

Once a job has been found, the race is not over. One merely discovers that it was one part of a decathlon which demands, for its next event, good job performance. I.T. does an impressive job of supplying students with the technical background necessary for today's challenging engineering and science careers, but this prepares the graduate for only one facet of a job. To be effective the young professional must be able to communicate ideas, manage people, express himself orally and on paper, and work with others. Unfortunately these are skills which are not stressed or improved significantly by a typical I.T. engineering or science course. But they are definitely developed by extracurricular activities. Recruiters know this and look for signs of it on a resume.

Minnesota Technolog is one of many fine activities and organizations waiting for your support this fall. As a "logger" (with all due respect to the forestry students) you will be able to sharpen your writing and proofreading skills, take part in the actual production of a magazine, or try your hand at selling ads to companies in the Twin Cities. We'll look great on your resume! And you'll be cultivating your interaction skills, meeting new and interesting people and, if you're not careful, having a lot of fun!

Alan Hauser

Al Hauser

Editor

TEXAS INSTRUMENTS
INCORPORATED

INVITES

UNIVERSITY OF MINNESOTA candidates for BS, MS, PhD in Design Engineering disciplines:

- **Computer Science**
- **Mechanical Engineering**
- **Electrical Engineering**
- **Industrial Engineering**

Come relax with us for an evening of wine, cheese and chit-chat at the Sheraton Ritz, 6:00 PM, Monday, October 17. Faculty of the above disciplines are invited.

DOOR PRIZE for lucky candidate: Texas Instruments Personal Computer Console.

Learn from Texas Instruments engineers (not professional recruiters) how Texas Instruments nurtures personal growth through innovation.

Following this informal evening, Texas Instruments will interview interested candidates at the University of Minnesota I&T Placement Office on the 18th and 19th of October.

BUS ROUTE: Simply take the 16A off of Washington Avenue.

If you missed us at the sign-up, catch us at the Sheraton.

Log Ledger

By Scott Dacko

- **Science and Technology Day**

Each year the Institute of Technology Alumni Society organizes and implements "Science and Technology Day." This year's S & T Day will be held November 11, and the theme will focus on civil engineering and the quality of life with the emphasis placed on public health. Tentative speakers for the event (which all I.T. students are encouraged to attend) are Minnesota Senator Dave Durenburger, Velvi Green from the U of M School of Public Health and Otto Strack from the Civil Engineering Department. The special guest speaker will be either William Ruckleshaus, Head of the U.S. Environmental Protection Agency or Allen Muir Wood, a preeminent British civil engineer. Further information on this event regarding times and places will be placed in the *I.T. Connection.*

- **Engineering Hot-Line**

Engineers can now call a special American Society of Mechanical Engineers (ASME) sponsored toll-free hot-line for a daily update on national news affecting their profession. The toll-free number is (800) 424-2989.

- **Winning Design**

A design for a lakefront museum—complete with retail stores, restaurant, garden, health spa, theater and marina—has won I.T. Architecture student Norman Barrientos $1,000 in a national competition. Sponsored by the Association of Collegiate Schools of Architecture and the American Wood Council, the contest required that the design be energy efficient and use wood. This second place award given to Norman Barrientos also brought $500 to I.T.'s School of Architecture.

- **Consulting Scholarships**

Five Institute of Technology students have been awarded a total of $3,000 in scholarships from the Consulting Engineers Council of Minnesota. They are Glenn Scroggins, Steve Brown, Gottfried Millner, Earl Mattson (civil engineering majors) and Brian Schmitz (mechanical engineering major). Each recipient received a $600 award at a recent CEC/M monthly meeting in Bloomington.

The scholarship program is open to any student currently in the sophomore or junior year of an engineering program. Application dates for next year's competition will be announced in October of this year, and students wishing to receive an application as soon as they are available may call the CEC/M office at (612) 922-9696.

The Science and Technology Bulletin Board

- **Anniversary**

The American Society of Mechanical Engineers will mark the 100th anniversary of its Codes and Standards program during 1984 with the theme, "A Century of Progress through Voluntary Action." The first performance test code was issued in November 1884.

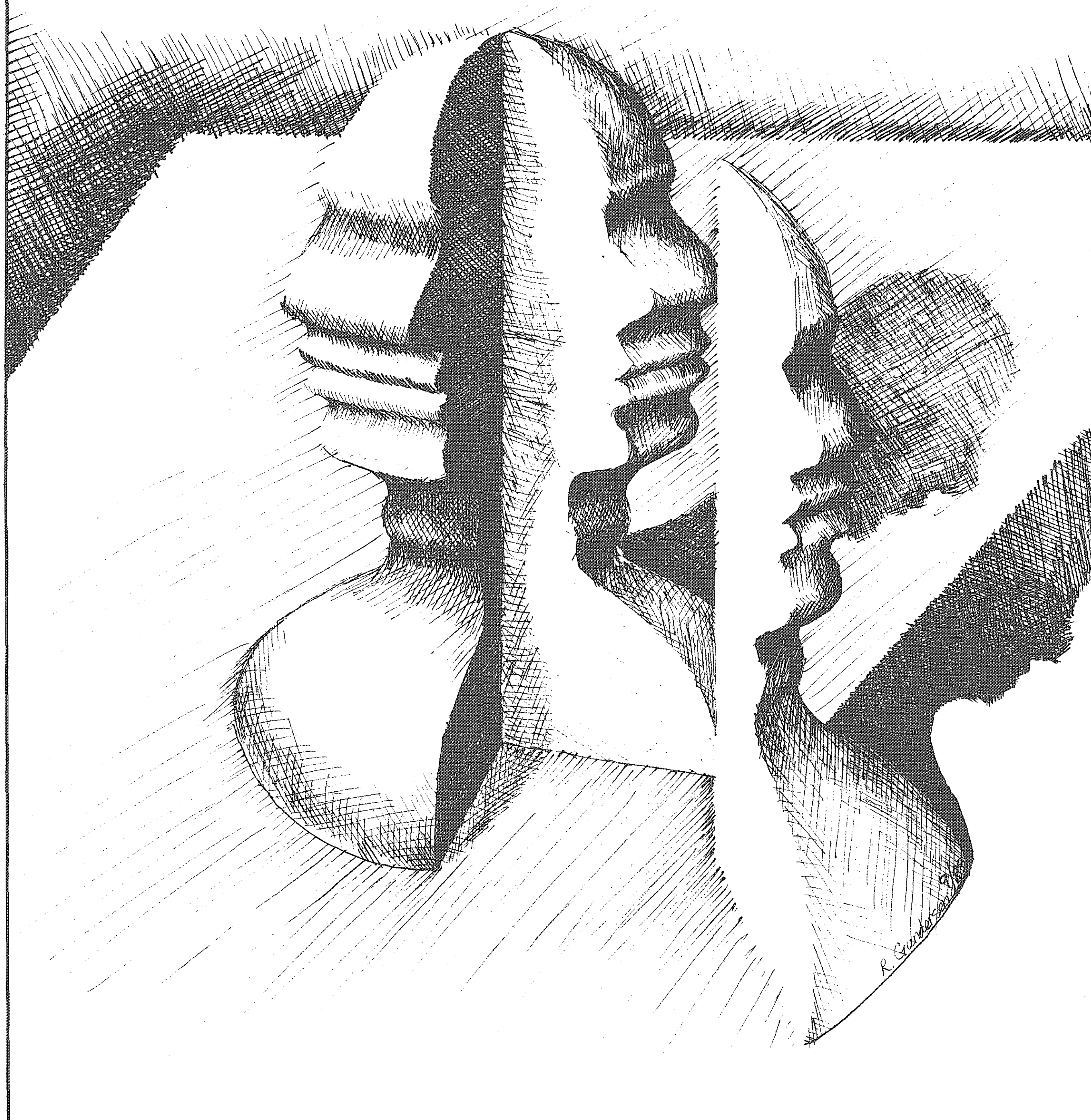
- **Powdered Coal Automobile**

Researchers at the General Motors Advanced Product and Manufacturing Engineering Division in Warren, Michigan are studying the feasibility of a micronized (powdered) coal-powered automobile. The researchers have designed and tested an Eldorado Cadillac with a gas turbine engine and a coal dust delivery system. The coal system includes a tank to hold the "fuel" and a chain-type pump to mechanically carry the coal dust to the fuel nozzle. Because of the prototype nature of the vehicle, the tank is under the hood and its small size provides 50 miles of fuel. Commercial tanks would be much larger and placed in the rear as in most cars available today.

Coal can be processed into gasoline, diesel fuel and methanol, but the capital expense is high and the liquid fuel retains only 55-70 percent of the energy value of coal. Powdered coal, which can be easily mass-produced, retains 78-95 percent of the coal's energy value.

- **Fair**

More than 11 million people visited the Knoxville World's Fair in 1982, which is more than twice the population of Tennessee and more than 1,692 times the population of I.T. The fair's theme was "Energy Turns the World." ■


R. Gunderson

Can Mortal Man See Higher Dimensions?

By Mike Doran

What an incredible visionary a human being is. The mind's eye has helped make machines which fly to the moon and M&M candies which melt in your mouth and not in your hand. His mind sees the past and looks into the future. He sees the surrounding life, yet also peers at the twilight zone, at those dimensions beyond. But just how much can man see? Can he really see the dimensions beyond—the fourth dimension, the fifth, and so on?

"I don't think so," said University mathematics Professor Robert M. Hardt. "But I know some mathematicians say they do. I do think we can understand further dimensions by analogy, but there is a gray area between intuition and perception." Hardt gave an analogy relating the movement from the second to the third dimension and the movement from the third dimension to the fourth. "In moving from the third dimension to the fourth, surfaces lose their closure properties."

If Hardt's analogy is not difficult to understand, it probably should be. The understanding and communication of vision, the mathematical and nonmathematical definitions of dimensions and further dimensions, and abstract geometrical concepts such as closure properties have occupied human thinking since man first drew pictures of saber-toothed tigers on cave walls. These ideas and definitions have been compiled and furthered by the likes of the Egyptians and their depthless drawings and hieroglyphics, the Greeks and their geometry, Descartes and his Cartesian geometry, Newton and his classical concepts, Einstein and his relativity, and today's computer wizards and their CRTs, to name just a few. Such a vast assortment and accumulation of knowledge is not easily picked up nor understood. Also, in the past mathematicians like Hardt who have dealt with the likes of visualizing further dimensions, a subject which seems so mystical and metaphysical to begin with, have been viewed capable of casting spells and uttering incantations as well. Today mathematicians and scientists face a leeriness and skepticism similar in nature to that of the past—as does almost anyone who presents opinions on unfamiliar ideas.

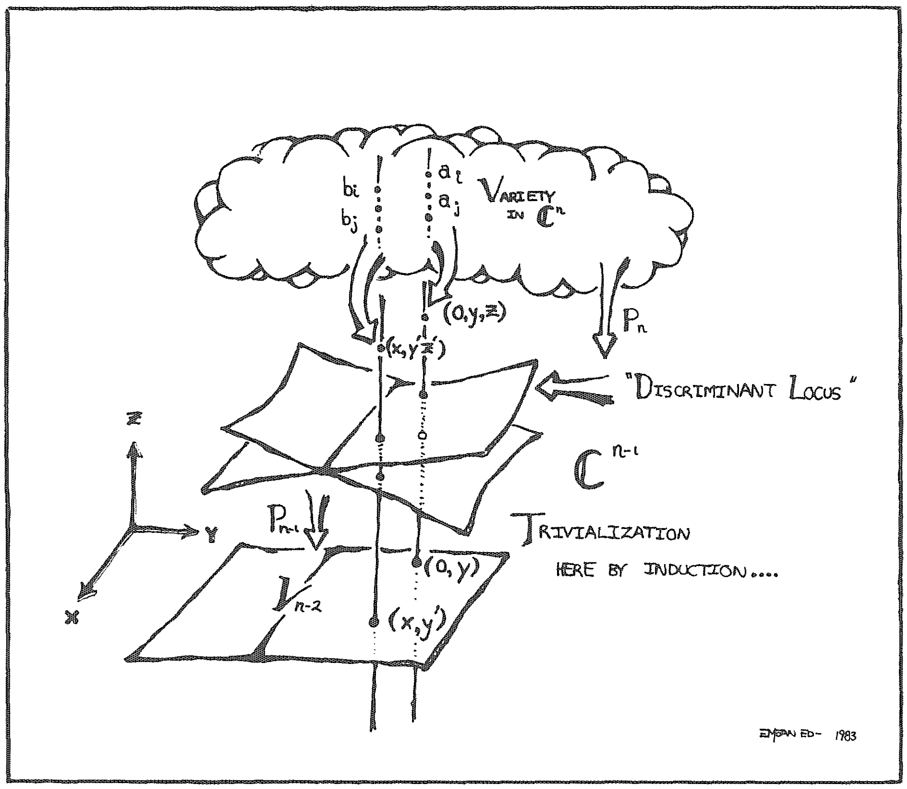
So the common mortal might cautiously inquire as to what professor Hardt means by saying the fourth dimension cannot be visualized but understood by analogy. In particular, what does he mean by, "In moving from the third dimension to the fourth, surfaces lose their closure properties."

Well, closure properties can be explained without much difficulty. One can imagine a line on a two dimensional screen. In two dimensions the line is "open." Now one can imagine a circle on a two dimensional screen with a dot inside it trying in vain to escape from the boundaries of the circle. In two dimensions the circle is closed. One can also imagine the circle on a flat, two-dimensional screen moving into three dimensions (also called space or the hyperplane.) The point is free to escape the circle without crossing its boundaries, like a lion jumping through a hoop. The circle has lost its closure properties in moving from the second dimension to the third. Points enclosed within circles should not be told of this property, however, because they would start demanding more space! (Sorry, pointless joke.)

The idea of losing closure properties is extended, then, by Hardt from the visible second and third dimensions to what he feels humans cannot visualize, the fourth dimension.

For instance, all humans can visualize the next step up from a two dimensional circle: a three dimensional sphere. Most humans can also perceive a point inside a sphere trying in vain to escape. The sphere has a closed surface in three dimensions; the point inside the sphere, like a piece of candy inside a balloon, cannot escape without crossing or bursting the balloon's walls. When the sphere moves into the fourth dimension, into hyperspace, the sphere's surface theoretically loses its closure properties. However, most people are unable to visualize or perceive this even though they have an intuitive grasp of the closure property. Yet, like Hardt himself pointed out, there is a gray area between perception and intuition. And his analogy may allow some people to perceive four dimensions.

Moving the balloon into four dimensions would be a clever way of getting the candy outside the balloon's walls without bursting it. And yes, it can be done. One just adds the dimension of time and moves the balloon across the room. The piece of candy would then be outside of where the balloon's walls formerly were, and the walls would remain unbroken. Of course, the balloon's



Notes taken during a mathematics class in which the higher dimensions of space are represented by an abstract cloud above the coordinate axes.

walls have to be broken to eat the candy, but the fact remains: the addition of the dimension time to the three dimensional balloon made it lose its closure properties. Can one visualize this? If so, one has perceived four dimensions.

University visual psychology Professor Al Yonas said that man's vision is a reflection of his environment, an environment which has three dimensional objects like balloons and time. Human vision evolved to fit the environment.

Vision seems to be inexplicably linked to time, and the movement it infers, whether one is watching or remembering Jessica Lange smiling or John Travolta strutting to the beat down the street.

"We live in a four dimensional universe, with time plus our three dimensional world," said University mathematics Professor Robert D. Gulliver. However, he said, "I don't really think we can see the fourth dimension; our experience with it is very limited. We have no way of moving freely in time, so that we don't have a complete understanding of it. Our understanding works by analogy."

Gulliver has a point. Can humans see time? If, for instance, humans try to visualize time, like trying to visualize both the balloon with its candy inside and time in the same process, must not the visualization include an infinite number of ballons with candy inside blurred across the room? Is this visible?

University mathematics Professor Donald Kuhn agrees with the basic space and time dimensions: "Time should be thought of as a dimension. The theory of relativity popularized this notion when it first came out." He also agrees with Gulliver about visualizing the fourth dimension: "We won't ever really see four dimensions."

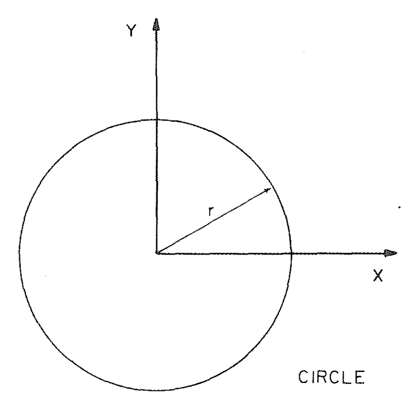
What Kuhn and others seem to be saying is humans live in a four dimensional universe, but can only see three dimensions. Yet maybe when humans look at cubes, cylinders, cones, balloons, or Jessica Lange, the objects themselves are three dimensional, but the act of visualizing these objects implies movement (or time) so that in the mind the objects become four dimensional. When one is asked to visualize four dimensional shapes, one again uses movement and time in the process so that in one's mind the shapes seem five dimensional. The act of visualization implies adding another dimension. For instance, if a blur results from attempting to visualize the balloon as it four dimensionally moves across the room, then this is probably an attempt to visualize four dimensions as a five dimensional time inclusive act.

Mathematicians like Kuhn are well qualified to talk about viewing dimensions because they think about and work with them so often. Their intuition comes from a great deal of experience. They may not claim to visualize or perceive higher dimensions, but they would certainly know what to expect if they could. They often solve problems analogous to dimensions which help send astronauts to the moon or make M&Ms as profitable and tasty as possible. Being able to visualize their problems is helpful for trying to better solve them, so that if humans could visualize higher dimensions, mathematicians would be among the first to know about it.

Mathematicians' ideas of dimensions are often more abstract than for most people, and often their dimensions have nothing to do with the familiar height, width, depth, and time. They are often variables in algebraic equations. Possibly the only way to visualize them would be to translate these abstract notions of variables back to height, width, depth, and time.

For instance, the equation with two variables (hence two dimensions) can also be represented visually as a two dimensional circle centered in a Cartesian coordinate space.

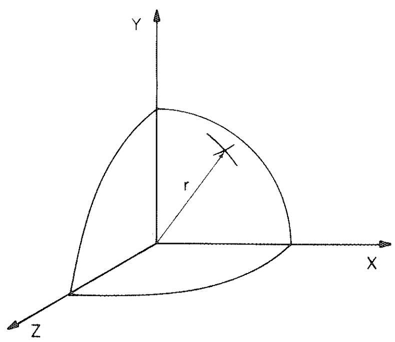
$$\text{radius}^2 = x^2 + y^2$$



The picture would have height and width.

The equation with three variables, hence three dimensions, can also be represented visually as a three dimensional sphere, centered in a Cartesian coordinate space.

$$radius^2 = x^2 + y^2 + z^2$$



FIRST QUADRANT OF A SPHERE

The image would have height, width, and depth.

But what of the equation with four variables, hence four dimensions:

$$radius^2 = x^2 + y^2 + z^2 + u^2$$

Can this be represented by anything? Can this four dimensional sphere be visualized? Similar algebra can be done to define dimensional cubes, called tesseracts; can these be seen? Mathematicians do know these higher dimensional shapes exist from their experience with algebraic analogies. Hardt, Gulliver, Kuhn, and other professors very familiar with these types of algebraic analogies say that the fourth dimension cannot be visualized.

But there may be more to the question of visualizing the fourth dimension than meets the eye. Recently one of the top wizards of mathematics, Princeton University's William Thurston, winner of the Feild Award, mathematic's version of the Nobel Prize, claimed in a Wall Street Journal interview to be able to visualize the fourth and fifth dimensions.

He said, "People don't understand how I can visualize four and five dimensions because they don't realize how people really think. Five dimensional shapes are hard to visualize, but it doesn't mean you can't think about them. Thinking is really the same as seeing."

There truly seems to be a gray area between intuition and perception. Perhaps perception is not that important. Professor Hardt is familiar with a famous geometrist, Pontryargin, who was blind. Professor Kuhn added along the same lines that no one can perceive zero dimensional points, one dimensional lines, and two dimensional curved lines because they are infinitely thin. Yet everyone seems to know what they are.

On the other hand, common vision seems linked to the physical environment's space and time, when thinking about two and three dimensional objects. Anyone can close their eyes and imagine an inanimate object like a still balloon, which is three dimensional, and then mentally rotate around it. This implies the addition of the dimension of time. Maybe Picasso's two dimensional paintings are so popular because they are very difficult to imagine in space and time. Two and three dimensional shapes, though subsets of space and time's four dimensions, seem easy to visualize. People do it frequently without thinking, possibly because everyone has a lot of experience with these types of objects.

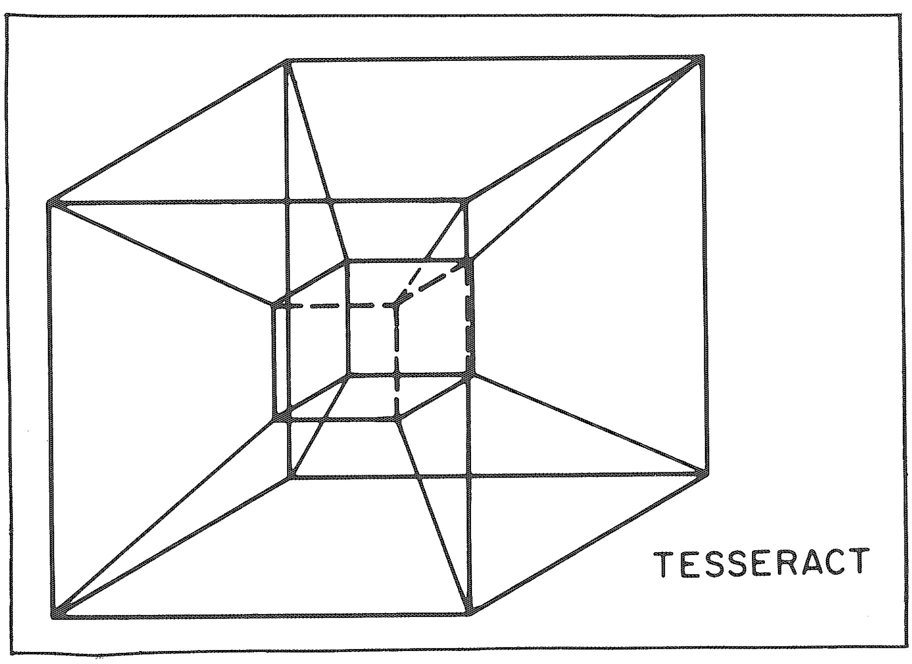
The human brain automatically interprets certain characteristics as an indication of depth as a result of visual experience. A photograph or painting, with the help of shading and differing sizes, is easily interpreted as three dimensional. This quality can also be deceiving and is responsible for many optical illusions. Past visual experience is the indirect cause of these illusions. The question to be asked is how much the lack of experience with four and five dimensional objects affects the common visionary.

Princeton's Thurston has had a considerable amount of experience with four and five dimensional shapes. Thurston has used computers as visual aids to help him visualize the higher dimensions, maybe with as much success as common mortals visualize Jessica Lange or John Travolta from a photograph or DNA from a computer simulation printout.

Another famous mathematics wizard and computer expert, Brown University's Professor Thomas Banchoff, uses computers to help visualize higher dimensions. He has also created films of higher dimensional representations.

A colleague of Banchoff's, University of Minnesota mathematics Professor William Pohl, believes that humans only perceive objects in space and time. He, however, did admit that, "you get the feeling that you're seeing higher dimensions when you see those films."

Some of the films use analogies from three dimensional space to explain the fourth dimension much the same way the story *Flatland* uses



TESSERACT

Continued on page 28

IT: Keeping Up With the Times

By Curtis Heiserman

Institute of Technology students return to the University of Minnesota this fall to participate in their chosen facet of a complex array of sciences. This complexity is a reflection of the ways science and technology have been adapted to all aspects of modern life. From the other side of the mirror, contemporary society is a reflection of the advances in science that have been discovered and developed since the onset of the Industrial Age.

Today, I.T. offers 20 degree programs focusing on everything from the earth to the stars—their composition, evolution and the application of such knowledge for the uses of man. Disciplines must be combined to push knowledge further in areas such as microelectronics, bioengineering or polymer research, forcing new programs to continually evolve.

So I.T. is an integral part of that which is modern. The I.T. student seeks to integrate his/her own knowledge, skills and career into the cutting edge of change and progress.

Chemistry Lab, ca. 1930

However the advance of technique, the inevitability and desirablity of improvements in technnology, was not always given so much attention by the University. The lifetimes of the oldest people among us span a change in emphasis from muscle power to nuclear power. The programs and growth of I.T. and, before it, the schools that became I.T. are a measure of this change.

By the end of the 19th century, the Morrill Act and its revisions had established the University and its administrative structure. The original mandate called for instruction in engineering; the College of Mechanic Arts was created In 1872. However, this provoked little response from the entering student of the day. As James Gray notes in his history of the University, "In the years 1870-1885, the courses in civil engineering and mechanical engineering produced between them a grand total of sixteen graduates, or 1.07 students per year."

It was not lack of money that kept people out of these classes. There was no tuition; only a five dollar incidental fee was charged annually. In spite of this, the University encouraged prospective students to learn a trade first, in order to support themselves while studying for their future careers, good advice, even today. But, for many the road to steady work is education first—a notion that inspired the creation of the land-grant university system.

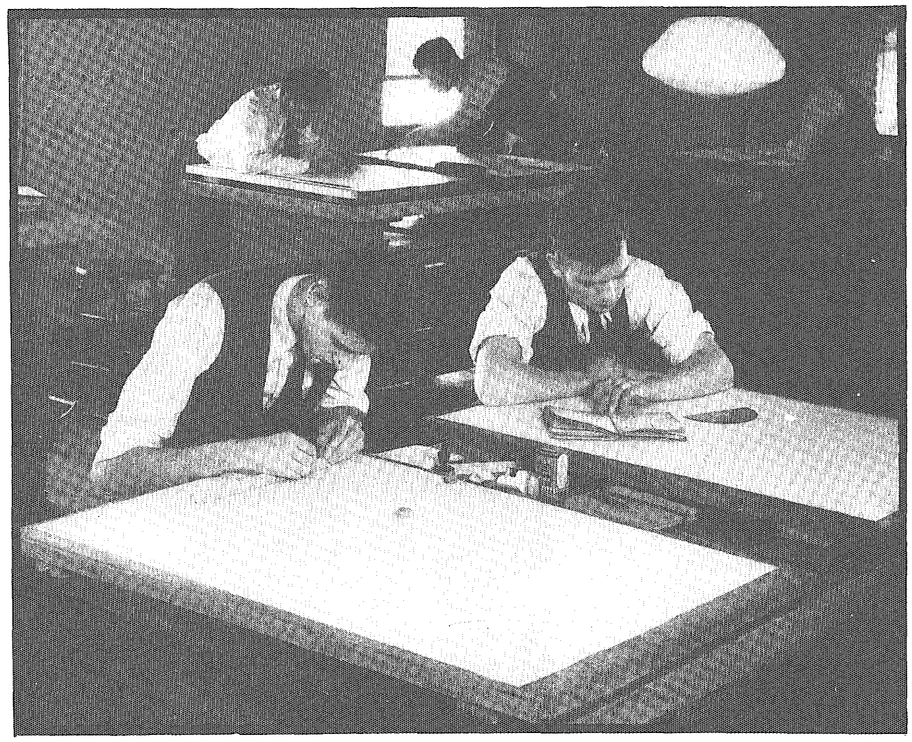
Not lack of money, but lack of interest kept them away. The feeling that the study of science and technology are vital to progress was missing even while railroads, telephones, and electric lights were beginning to shape a modern America.

The most popular schools in the 19th century were those training for professions in law, medicine, and pharmacy. Studying the classics drew the second largest group to the School of Science, Literature and the Arts.

The classical perspective is evident even in the entrance requirements for the College of Engineering and the Mechanic Arts. New students had to show a knowledge of the history of the United States, Greece, and Rome, as well as physiology and natural philosophy. Lower level courses included carpentry and military drill.

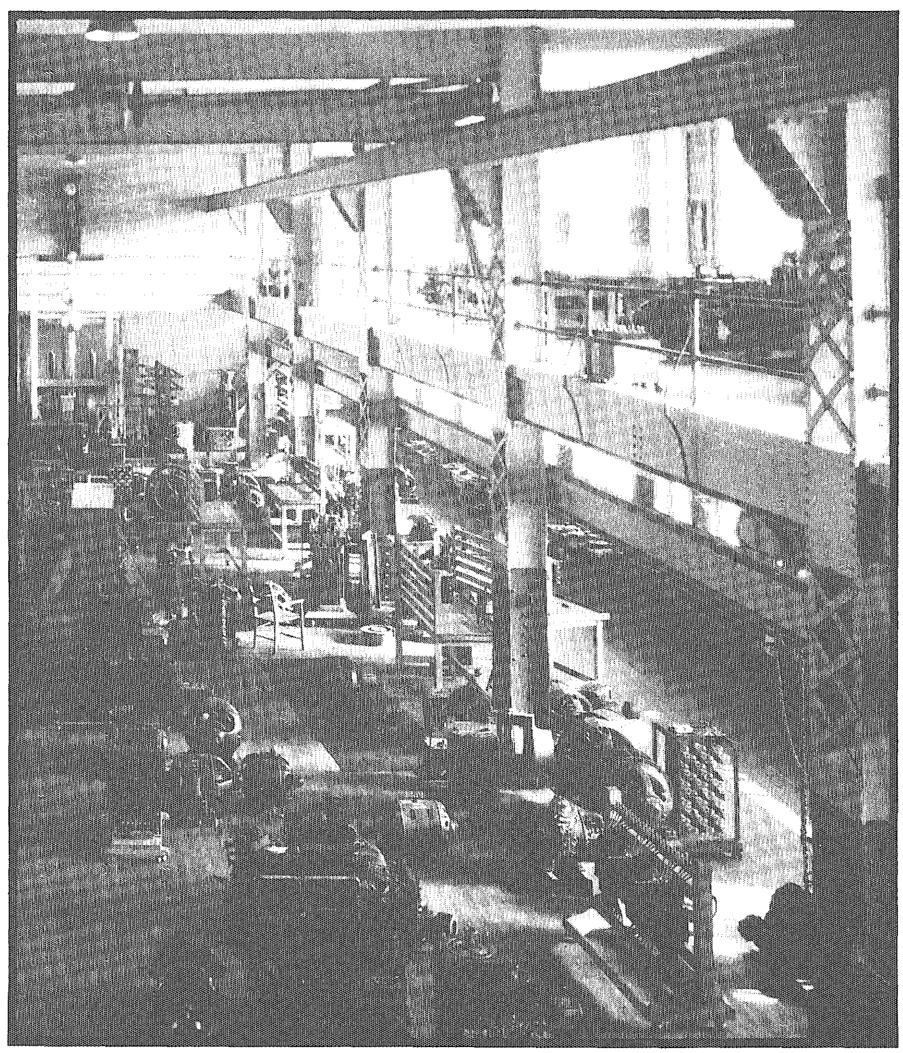
Gray quotes Arthur Beardsley on the latest equipment of the 1870s, "Towards the middle of the third term a compass and chain were procured, and the class (in surveying) received as much practice in the field as could be obtained without going out of hearing of the recitation bell..."

George B. Frankforter, Dean of the School of Chemistry, said in his report to the president in 1912, "The School of Chemistry was organized in 1896. At that time the demands for technical and applied chemistry were so limited that it did not seem wise to



Drafting class, ca. 1940

Electrical Engineering Lab, ca. 1930



Photo/Ed Wollack

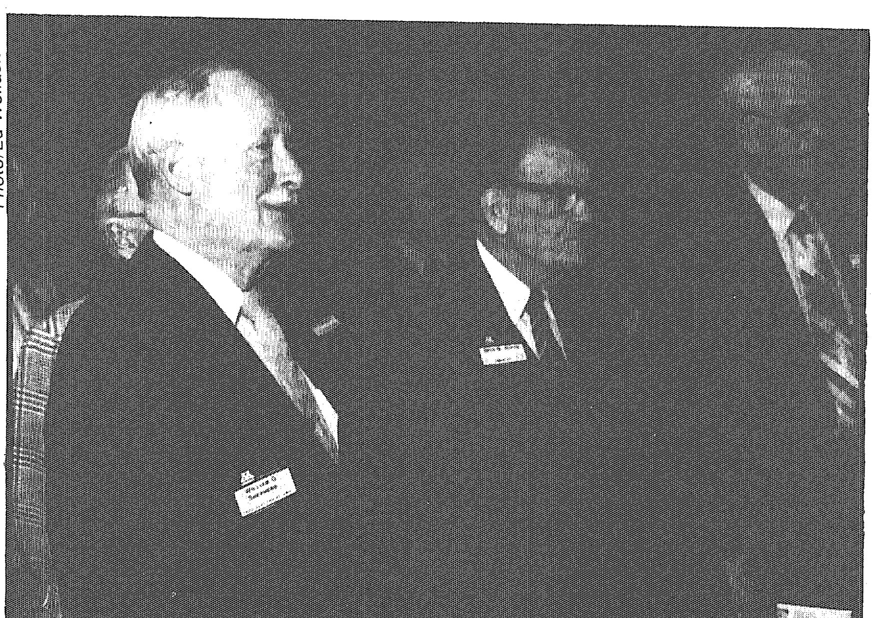
Elaine Battles, I.T.'s Assistant Director of Development, speaks to a group of alumni.

offer a course in these fields." By the time of this writing, however, the School of Chemistry had granted ten B.S. degrees in chemical engineering.

During this period of the industrialization of America, advanced work was not being done in the universities. Private labs and company scientists developed the latest technology. It was not until the post-World War II era that universities became fully competitive with such facilities as the Bell and General Electric laboratories. The outstanding engineer made his mark in private industry and then would sometimes return for a "professional degree" in engineering.

Members of the class of '33.

Photo/Ed Wollack



In the first three decades of this century, the number of graduates in the applied sciences grew steadily. (See figure 1.) Automobiles and streetcars began to replace horses and carriages on the streets around the University. The construction of the Mall in the 1920s began to give the campus its modern look.

In 1927, one of the most distinguished scientists in University history, Arnold O. C. Nier, began his undergraduate work in electrical engineering. During an interview in his office in the Physics Building, Dr. Nier reflected on changes that have occurred since then.

"The level of all the courses in the engineering fields has gone up," said Nier. "When I was a freshman, we had to take one quarter of forge shop—this was a real hammer and anvil course—pulley shop, foundry, and metal casting."

"It was too much," continued Nier. "These were holdovers. Spilhaus got them out."

Athelstan Spilhaus was Dean of the Institute of Technology from January 1949 to July 1966. During his deanship the old categories of "military" and "civil" engineering were replaced with departments divided functionally, and the deservedly proud and independent physics department was incorporated into I.T.

When Nier was a student, there was no Institute of Technology.

"Graduate work in the engineering fields was a relatively minor part of the whole operation," said Nier. "In fact, you couldn't get a Ph.D. in engineering until 1935," (when the Institute of Technology was formed). "Someone in electrical engineering moved into physics by default. Or an engineer did a major work and then got a "professional degree" in engineering."

"I remember the first Ph.D. in engineering," said Nier. "It went to Guido Brunetti from the Iron Range in 1935 or '36. He was a year behind me. We were close friends."

Dr. Nier recalled other changes in the look and feel of University life.

"Very striking is the number of automobiles," said Nier. "When I was a freshman one of my friends had an automobile. This was very unusual. ROTC was required then. We had drill in the Armory and had to be on time. Physics lab always ran long, so we would park in front of the building, then take the car over to the Armory."

By 1930 engineering programs had still changed little. General, trade-oriented courses were familiar requirements. Advanced research and development were still a private endeavor.

The differences today drew the attention of host and guest alike at a reunion for the classes of '33 and '43 on May 20, 1983. A reception was held in the new Civil and Mineral Engineering building, itself an application of all that is new in architecture and engineering.

Edwin F. Stueben, Associate Dean for Undergraduate Affairs of I.T., stressed the change in the size of I.T. since these classmates attended. Stueben said that 1,033 students were enrolled in engineering programs in 1933. By 1943 graduate study had been eliminated for more active service of the war effort and the number of students had dropped to 897. In the fall of 1982, 6,318 students were enrolled as undergraduates in I.T.

"There are now more students in electrical engineering than in all of I.T. in 1933," said Stueben. "The big difference in this student population is that a large percentage are women today. I think there were two or three in 1933."

Don O'Hare, class of '43 and now vice chairman of Sundstrand Corporation, noted the physical changes in the University but said the biggest changes have been in engineering itself.

"I think there were more advances in technology in the last 40 years than in the whole history of engineering before that," said O'Hare. "It's more demanding today. That means there is a tendency to over-specialize. The risk is that narrow tunnel vision makes them ill prepared for management of the whole company."

O'Hare said another big change since his student days is the cost of everything. He had to pay out of state tuition in the '40s of $45 per quarter. This was $15 more than for Minnesota residents.

"That $15 was no small problem. I was very happy to get a job for 30 cents an hour," said O'Hare.

Cost per quarter was also

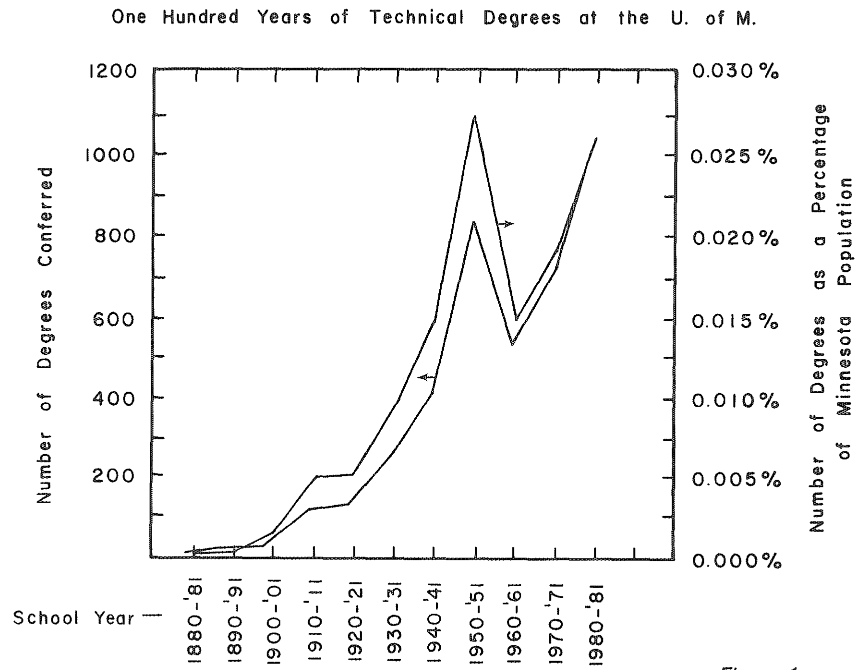


Figure 1

mentioned by Walter Spivik, class of '33.

"Since they charged like that—per quarter," said Spivak, "we took as many courses as we could—usually 19 credits."

Changes in style were noticed by Gayle Priester, class of '33.

"Back then we all wore these to class," said Priester, stroking his tie. "Cable cars used to run through the campus and connect up with the Lake Harriet line and over to the St. Paul campus."

By 1935 Priester was working for Carrier, developing floor units that fit into a window.

"'Room coolers,' we called them then," Priester said.

Priester went on to co-author a text, *Refrigeration and Air Conditioning,* that was used by 75 universities until the 1960s.

The graduates of the 1930s and 1940s began to create the technology that shapes so much of today's world. As Dr. Nier put it, "There was a great blossoming of advanced work in the mid-'30s."

Nier played an outstanding role in that advance. Henry Erikson's longhand history of the physics department, of which he was head for many years, understates one of Nier's discoveries. "In March and April 1940, Nier established U 235 as responsible for the slow fission in uranium. This gave rise to a great interest."

Not to mention a reshaping of world affairs!

With John Tate and John G. Williams, Nier made up a remarkable U. of M. trio that joined other scientists in a nation-wide effort to design and build an unbeatable war machine. The history of their contributions is an integral part of the history of World War II. This combined effort so drained the universities that graduate study became impossible.

But with the end of the war, schools were flooded with applicants funded by the new GI Bill. Dr. Nier pointed out that these soldiers were well aware of the importance of technology from their experiences in combat. From sonar and radar to the long-range P-51 Mustang and nuclear weapons, technology developed for the Big One had defined the character of Allied victory. America was convinced of the value of technological advance.

The number of graduates from the Institute of Technology doubled from 1940 to 1950. Nearly all of that group was due to the post-war influx.

The federal government bolstered scientific work in universities after the war in another perhaps more significant way as well. The Office of to develop a post-war grant and contract program to continue critical research. As other agencies, from the Atomic Energy Commission to NASA, created similar programs, they patterned them after the ONR model. Prior to the war the faculty could only appeal to the University for more funds.

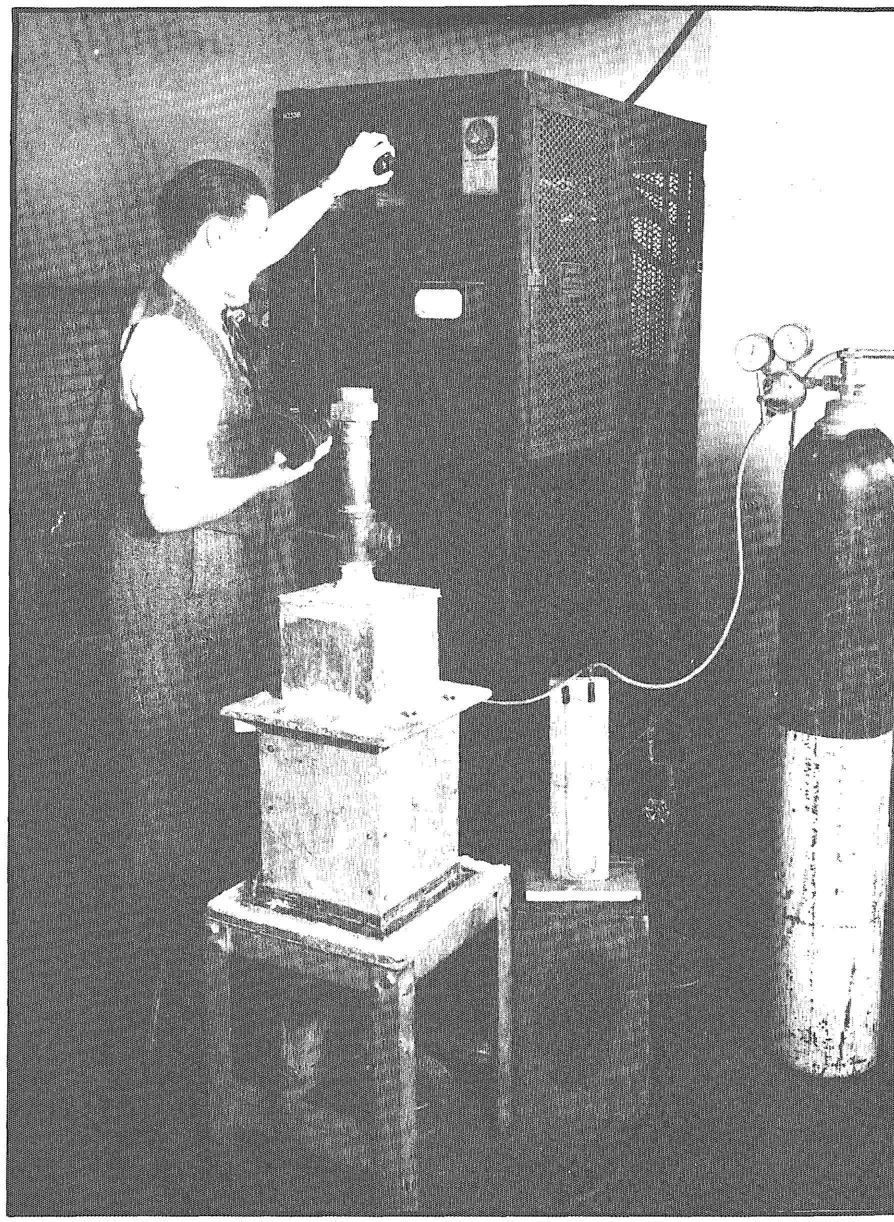
"This was pin money compared to what became available from the federal government after the war," said Dr. Nier. "We could buy or build modern laboratories and could suddenly do real things, not just play with toys. Research and development could now be done on important problems on a big scale."

In fact, the role of engineering colleges changed dramatically. They continue to train new scientists and engineers but now are also at the forefront of new research. For the 1982-83 school year the academic operating budget of I.T. was $20,685,000. But sponsored research more than doubles that budget with a value of $22,000,000. In fact, outstanding active research is the *sine qua non* of a modern academic program.

Today a career in engineering is likely to trace the interlocking system of funding and research formed by government, industry and academia. Each competes with the others to attract the brightest minds and the richest research contracts. Such competition reveals a close working relationship. Since World War II this relationship has been viewed as essential in order to insure that the latest discoveries are available to government and economy alike. Information is the payback.

As society asks for technological solutions to problems from food production to space weaponry to global information sharing, the student body of I.T. is again experiencing major growth. Will tomorrow's scientists be able to anticipate problems and discover their solutions with sufficient efficiency to prevent societal disruptions such as occurred in the 1930s and 1940s? Is I.T. helping to prevent the tunnel vision O'Hare warned against so that, not only corporations, but governments and universities can see the broader impact of their programs? Who will call the tune and who will lead the dance as science and society go hand-in-hand through the next few decades?

Today the number of graduates from I.T., expressed as a percentage of the state's population, again approaches the post-World War II level. Entering students are responding to a perceived demand for expertise in technology related fields. As a society asks for and gets a new flood of technological experts, more dramatic changes may be in store. New techniques of production and handling of goods and information may make the University of today seem as backward to our grandchildren as the required courses of the 1920s seem to us. How to incorporate the new into a pattern of stable growth, responsive to real needs, remains the elusive goal. ■



Mines Experiment Station, ca. 1930

Curt Heiserman is a graduate student in the School of Journalism. Although he has been going to college for a long time, much of the information in this article was not from firsthand experience.

Staehle and I.T.

By Scott Dacko

Roger Staehle came to the Institute of Technology four years ago from Ohio State with one purpose in mind as the new I.T. Dean: to increase the quality of I.T. education. And until his resignation this past May and the appointment of Rama Murthy as the new I.T. Dean, Staehle has put forth strong efforts in every facet of Minnesota education, business and government in order to achieve this goal.

Staehle's accomplishments are very impressive. Among his initiatives were:

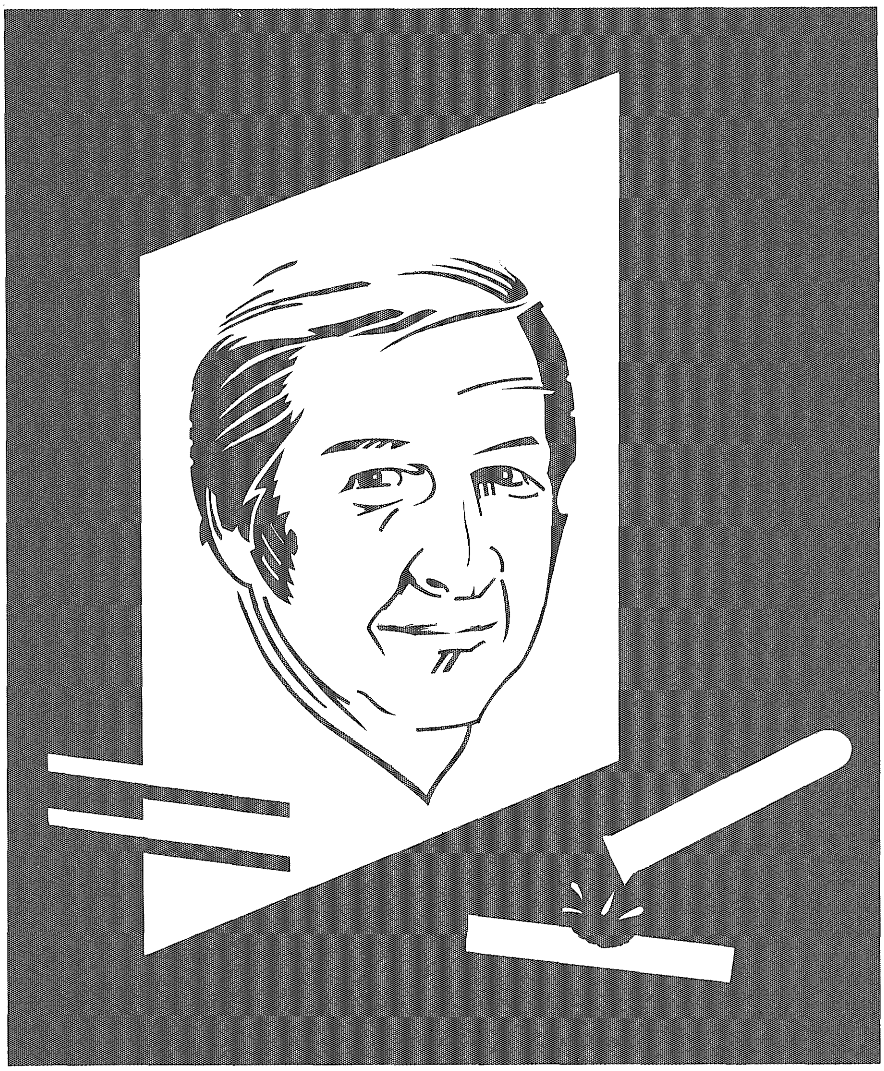
- The formation of the Minnesota High Technology Council (MHTC), a group of business leaders which has quickly become a powerful educational lobbying group.
- The formation of Minnesota Wellspring, a coalition of business, education, labor and government to stimulate jobs through technology.
- The formation of the Microelectronics and Information Sciences (MEIS) Center, a university-business venture in I.T. initially funded by Control Data Corp., Honeywell, Sperry Corp. and 3M Company.
- Centers within I.T. for corrosion research, applied mathematics, productivity and biotechnology have been started along with a program to improve elementary science education.
- The appropriation of 14.2 million dollars in additional state funds was approved this spring for high technology programs in I.T. on the Twin Cities and Duluth campuses, partly due to Staehle's efforts. In addition he raised more than 12 million dollars from various business contributors.

Now that Staehle will no longer be dean, one may be curious as to which steps he feels I.T. should take to continue to increase the quality of its education. According to Staehle there are three areas which need major attention. The first is to re-equip the laboratories. Newer, high quality equipment, Staehle says, will get the students back into the laboratories where they can continue to learn by doing. Secondly, Staehle feels an emphasis should be placed on increasing the number of faculty. And thirdly, Staehle feels an effort should be put on teaching the students something they are not being taught: organizing people.

"According to Staehle there are three areas which need major attention. The first is to re-equip the laboratories. Secondly, Staehle feels an emphasis should be placed on increasing the number of faculty. And thirdly, Staehle feels an effort should be put on teaching the students something they are not taught: organizing people.

Commenting on this priority Staehle says, "Our greatest concern is organizing the affairs of people. In the formation of a business, for example, unless you can meet the needs of people and unless you can get people to work together to make it (a product), you can't make it."

Staehle perceives a process similar to that of a senior design project but different in that it would involve groups of 5-20 students working on the formation of a business. The group would have to determine what to make, a market strategy, a financial plan, how to raise the money, how to hire people—the entire start-up process. And, Staehle says, "The ultimate jury would be the capital/banking community. Each member of the group would make a presentation on their particular aspect of the business formation, and since the business as a whole is affected by the strength of each area, everyone would receive the same grade. Students *for the first time*



majoring in "extracurricular activities."

Ideally, Staehle would like to see every student in I.T. writing 20 pages a week and speaking 30 minutes a week. Since presently this is not possible in the classroom, outside student activities, he says, are invaluable. As the I.T. dean, Staehle has given much support to the I.T. Student Board, "The I.T. Connection," *Minnesota Technolog*, the I.T. yearbook, as well as all other I.T. student organizations.

After all that Roger Staehle has done, one would hope that he stays in Minnesota to somehow continue his collaborative efforts. Presently Staehle is utilizing his chemical engineering background by writing a complete design handbook on the mechanical properties of materials. While maintaining a tenured position in I.T.'s Chemical Engineering Department, he will at the same time continue to do consulting for several businesses, work on some state government projects, and it appears that he will teach this fall in chemical engineering. Whatever his plans are for the not-so-immediate future, we can be certain that with his emphasis on high quality, he will be successful. ■

would have the feeling of forming an enterprise."

There are, of course, many other ways of improving I.T. education, such as expanding the student intern program, Staehle believes. In addition to this, however, the former dean feels emphasis should be placed on the graduate school. "The graduate school is too small to support what ought to be here," Staehle says. "Instead of 1,500 students we should have 3,000 students. And this isn't just good for Minnesota. Increasing the size of the graduate school is a direction the entire country ought to be going."

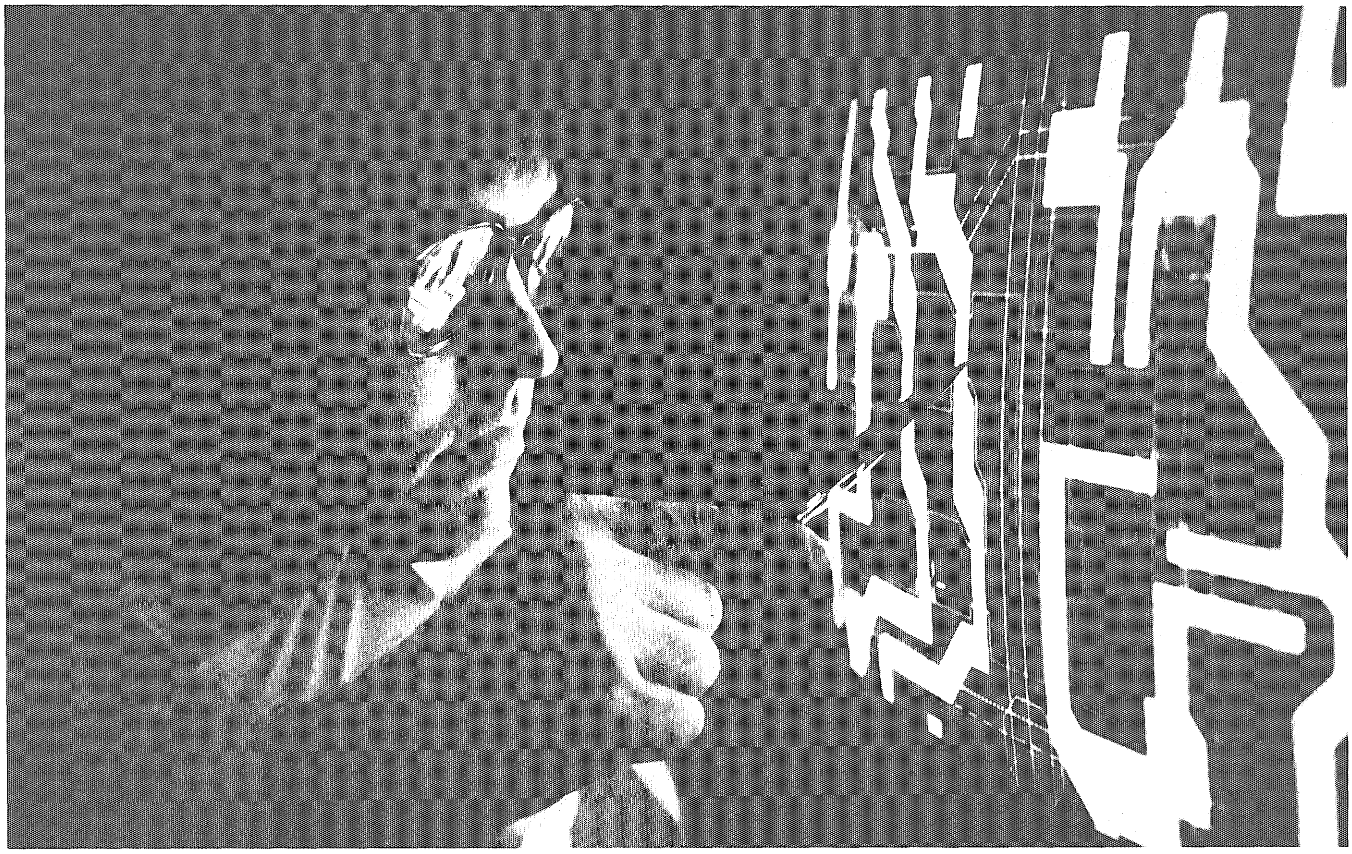
Also to strengthen Minnesota Staehle has suported collaborative efforts between education and industry. "The process of collaborating is our future," Staehle exclaims. "That's basically why this country has so many lawyers. People are unable to work together. They have to have someone else say it for them. And not only is the future of Minnesota dependent on working together—the university, labor, business and government—but the future of the whole country depends on it."

In addition to emphasizing a quality education within the classroom, Staehle has always pointed out the many advantages of college extracurricular activities. Whether it be writing for a publication, participating in student government or being active in a fraternity or sorority, all are beneficial, he says. "College is a great proving ground," says Staehle. "It's a place where you can make mistakes and nobody cares. When you get out into the real world it's different—your job might be on the line." When attending college at Ohio State, Staehle was said te be

Note: This article was not meant to delay the welcome of the new Acting I.T. Dean, Rama Murthy. Formerly Associate Dean and head of the Geology Department. Murthy will be interviewed in the next ***Minnesota Technolog*** *where he will discuss his plans for continuing efforts in increasing the quality of education in I.T.*

Scott Dacko is a mechanical engineering senior. He has written for *Technolog* since he was a freshman and plans to continue to do so until he dies or graduates, whichever comes first.

Come up to Sperry



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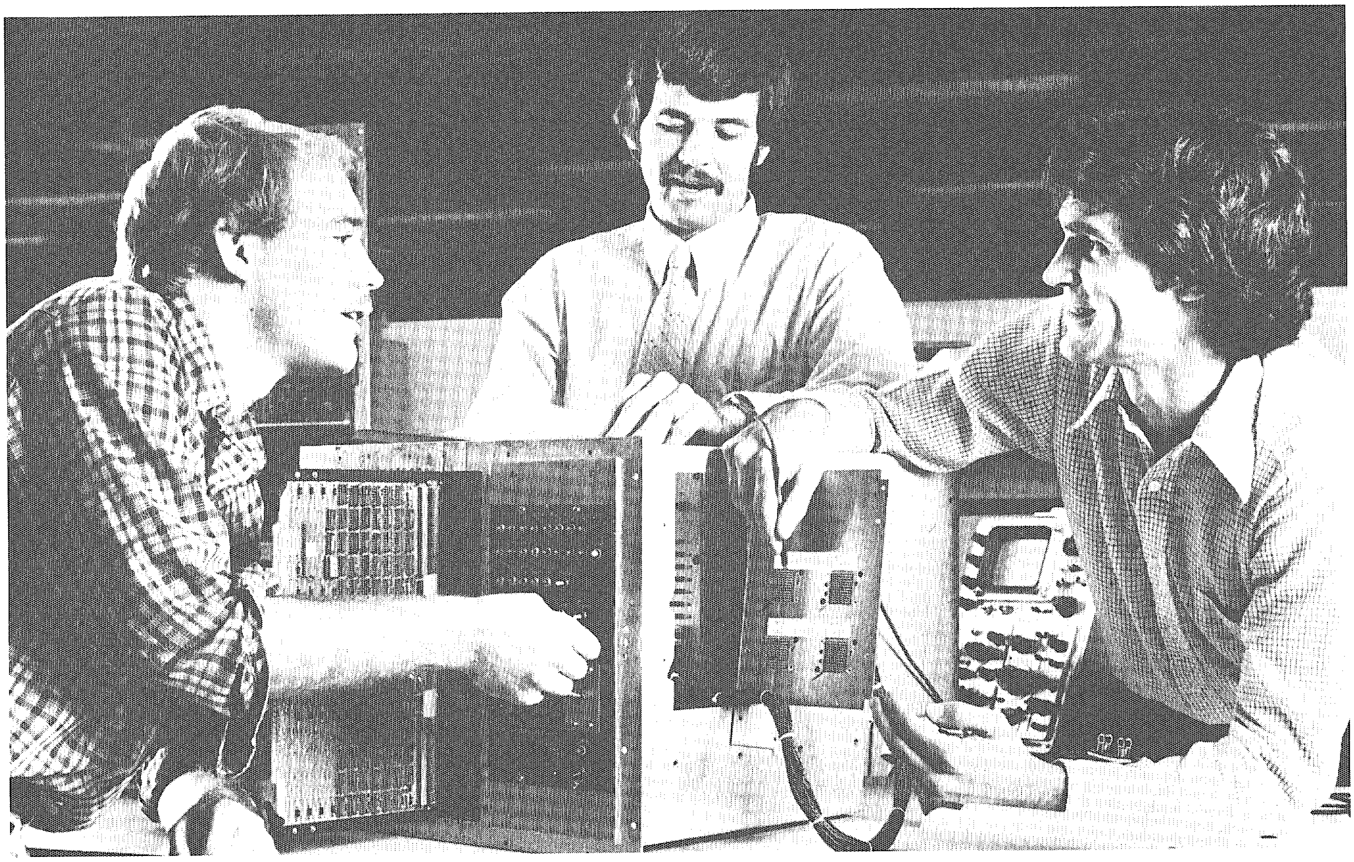


The Fantasy World of Solaron

By John McGarthwaite

The best definition of Solaron would have to be that it was like the Renaissance Festival but on a futuristic level.

After paying the five dollar entrance fee and receiving our tags we went to the entrance tunnel where we were greeted by inhabitants of Solaron at Buck Hill Ski Area in Burnsville, July 15-31. After a quick trip through the tunnel we entered Solaron. To fully enjoy Solaron we tried to think of the characters not as actors, but as people. Upon making that adjustment, the story of Solaron came clearly into focus.

For many centuries the planet was ruled through the powers of the Crystal Monolith. Due to "personal failings" the powers were lost, and now it exists as an authority symbol. A Matriarchy exists on the planet with Lady Gallestra currently ruling. Years ago Lady Gallestra felt Solaron would need a better leader so she sent her own heir off-planet to be raised, but in route the spaceship was attacked by pirates and nothing was heard from it. Lacking an heir the people are in confusion and certain factions are contesting Gallestras rule. In the hopes of bringing a future to her planet, this reception, which we were part of, was given.

What we saw was truly reminiscent of the Renaissance Festival. There were artisans, performers, visitors, and of course the Solaronese. First we (photographer Mark Thompson and I) looked around and later stopped so Mark could try to send some "obnoxious" clones into the water. He did it. Then things on Solaron started jumping.

The officers of the IPL (Interplanetary League) were given orders, then dismissed. A short time after that our camera came under scrutiny because they thought it was a weapon, and in his effort to explain Mark called it a light absorber. We then happened upon the attempted kidnapping of Kitsym Nemo by the men of Napoleon Warpslayer. Warpslayer's men were stupid enough to tell her what they were going to do, so all failed. Kitsym and Warpslayer then argued about how he should help her and others thwart the Viceroy's plans.

After some research and interviewing I found what was going on and who was to play a major role. This reception had been called to choose who Solaron would align with. The two main contestants were the IPL, led by an ambassador and

Photo/Richard Ericson

A used robot salesman.

Photo/Richard Ericson

The evil Viceroy and one of his soldiers.

Ton Quist, commander of the Galactic Patrol, and the First Dominion represented by the evil Viceroy. Gallestra had been warned of the "conquer and enslave" policy of the Dominion. Kitsym, another person to watch, was the lost heir of Solaron and a medallion around her neck gave proof of that.

The next thing seen was the initiation of two Staves, the warriors of Solaron. Following the ceremony we ventured into the Cosmic Cafe and drank some "carbos". We then ventured out into the intense heat and found Kitsym in the arms of Ton Quist. This rendezvous proved to be beneficial when Quist saved Kitsym from the clutches of the Viceroy after she recovered her medallion, which had been taken earlier.

An hour later, the IPL offer was accepted by Lady Gallestra down in the village at the main stage. Learning of this the Staves and the Viceroy met and plotted against her; shortly thereafter they carried out their plans at the Monolith. Napoleon Warpslayer, his men, and the Galactic Patrol were informed of Gallestra's plight at the Cosmic Cafe and rushed to her aid. All this led to a battle between all the factions at the Monolith. Following the inevitable triumph of good over evil, the true heir of Solaron, Kitsym Nemo, was crowned.

In addition, there were the exhibits and displays. The University of Minnesota displayed a diagram of an electron microscope and some photographs taken by it. Another exhibit was the Kofutu Healing System and Kirlean Photography. This is a process which photographs the electromagnetic field around the body. The photographs show areas of tension, which can then be treated. We were skeptical of this, since the lady we talked to said a man with herpes had had no further outbreaks since being treated by this method. There were also many other exhibits such as the following: fantasy games by Grand Games, music disks by Audio Perfection, science fiction movies courtesy of Video Concepts, Save the Children, Honeywell, KQRS, National College, Citadel of Stars, and much more. Lectures were given, although poorly attended.

The only thing "out of this world" about the food was the exotic names given to everyday beer, pop, nachos, and others.

Solaron was quite interesting. We left with the feeling that we had been to another world. ■

Photo/Mark Thompson

A villager and two members of the Interplanetary League.

One of Solaron's many inhabitants.

Photo/Mark Thompson

John McGarthwaite is a CLA sophomore intending to major in journalism. Since writing this article he has left for Solaron to join in the fight against the evil Viceroy. He was last seen near the Andromeda system.

The Graduate

The I.T. Placement Office: An Institution of "Hire" Education

By Karen Auguston

This is the first in a series of six articles designed to help the graduating I.T. senior. Each issue of **Technolog** *will contain one article on such topics as the following: effective interviewing, working for a large corporation, working for a small company, and graduate school.* **Technolog** *hopes to answer many of the questions facing students who are preparing to graduate.*

"Last year was probably the worst year in the 25 years of Placement Office operations."

Lee Ponto, Director,
I.T. Placement Office

Fewer companies on campus, a larger number of candidates and increased competition for interviews all added up to a tough year for college graduates seeking jobs last year. While engineering degrees are still in relatively high demand, placement figures in recent years reflect a depressed economy.

I.T.'s placement record has been outstanding. In the past, student placement has routinely reached 95%, with students averaging four or five job offers each. Two years ago, however the number of students obtaining jobs through the Placement Office fell to 75%. Although statistics for last year are not available yet, Lee Ponto, Director of the I.T. Placement Office said, "I would guess as many as 50% of last year's graduates are still looking for work. We had a situation last year where even the fairly good applicant was not receiving any job offers." The lack of student response to a questionnaire sent out early this summer by the Placement Office has caused the delay in obtaining actual placement figures for last year. Although the office has begun calling students, it may take several months to complete the survey.

Campus recruiting continues on a downward trend. From a high of nearly 300 companies visiting the campus in the early 70s, the number has steadily declined, while the number of engineering graduates has doubled. Last year the number of companies interviewing on campus was down 40% from the previous year. Of these, 15% were cancellations due to an overestimation of hiring needs. Despite recent reports of an economic turn-around, about the same number of companies have indiciated they will be making campus calls this fall. Ponto said that an economic recovery will probably not immediately affect campus hiring. "We do not foresee a dramatic increase in the number of companies coming this fall." Historically, it has taken several years after a recessionary period for engineering demand to return to normal activity levels on campus. "Given the particular severity of this recession," said Ponto, "we can expect a longer recovery period."

According to Ponto companies curtail campus recruiting efforts during recessionary periods. "With recruiting costs rising, a company may cut costs by visiting only the campuses located nearby, schools where they have had previous recruiting success, and the larger campuses." For students at the University of Minnesota, many of whom express an interest in remaining in the Metropolitan area, this may be an advantage. 3M, Honeywell and Sperry Univac, all Minneapolis-based firms, have done heavy recruiting in the past at Minnesota. Also encouraging, IBM has announced intentions to be number one (in terms of numbers hired) on campus this year.

With their contemporary training and originality, new graduates bring fresh ideas into the work place, and companies recognize this. Although no real hiring needs may exist, companies continue to recruit. According to one recruiter, "We really can't afford to miss out on (recruiting) even one graduating class. When things improve that group is lost forever, and they represent the future of our company."

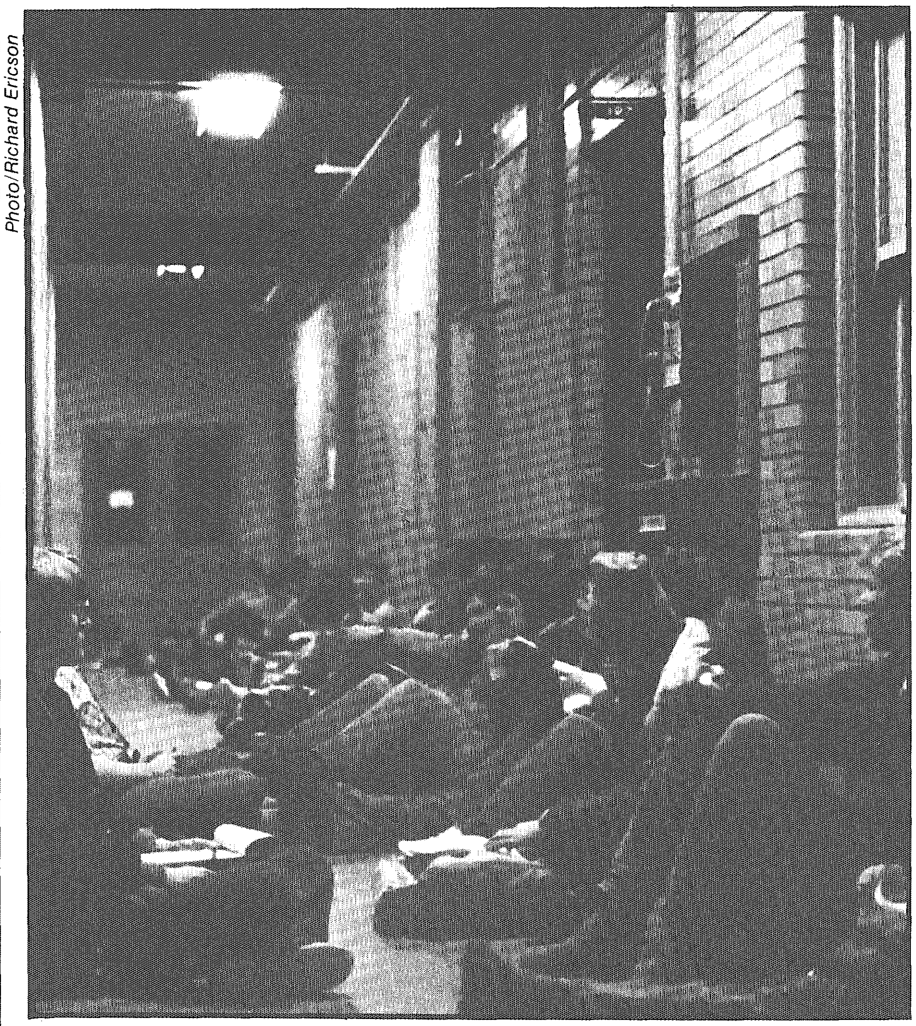
Students may view the greater selectivity of many companies as an indication of no openings. "Other than public relations, there really would be no reason for a company to make a campus visit if they had no hiring needs," Ponto said, "And we do discourage that." With fewer positions available, companies appear on campus looking for only the best candidates. This creates competition not only among the students seeking jobs but also the companies who are looking for the outstanding student. Even in a tight market, a top student may still receive as many as eight or nine job offers.

Competition for interviews increased last year because of the drop in campus visits and student anxiety over a tightening job market. Student usage of the placement office was heavy; about 1,000 students were registered. Although the first-come, first-serve sign-up system worked well in the past, Ponto said, "It was the overnight stint last January that prompted us to revise the system." Last winter nearly 200 students spent the night in the Experimental Engineering Building to sign up for campus interviews. Ponto recalled some overnighters in the 60s, but said that, "Even then, it wasn't anything like last year."

For the remaining sign-ups last year, the system was converted to an alphabetical rotation. Students were randomly assigned specific sign-up times according to their last names. Although this system shortened lines and put an end to future campouts, it was not always the most equitable. When students are scheduling interviews without regard to the company, "it isn't a good situation," said Ponto. One recruiter had his schedule completely filled with students whose last names began with the letter "S". "And you know, I'm wondering if they are all really interested in our company," he said. Nevertheless, as a short-term solution, the system worked fairly well, "and with few complaints," said Ponto.

Computer-aided interview scheduling is about to take its place assisting operations at the Placement Office. I.T. will implement a new computerized system this fall similar to the one presently used by the School of Management's placement service. With more majors and companies, I.T.'s system will be more complex but the procedure will be identical. "This type of system is more popular right now in placement offices throughout the country," said Ponto. "It seems to work fairly well."

Most students are familiar with the Monte Carlo computer simulation, but this operation will more closely resemble the famous gambling casinos of Monte Carlo. It will utilize the point bidding system, where students will list companies with which they wish to interview and attach a priority to each. Current graduates, who receive preference in scheduling interviews, will be allocated approximately 1,000 points which can be distributed in any manner the student wishes. The number of points allocated to alumni and students from other colleges will be assessed proportionately. Because the student can distribute his points as he chooses, there are elements of adventure and risk to the system. For example, a student could list ten companies and distribute his points equally among the entire ten. However, an individual may attempt to increase his chances of securing an interview by bidding more points on certain companies. For instance, he may bid 500 points each on the top two companies on his list.


Photo/Richard Ericson

The halls of the Placement Office will hopefully remain free of last winter's long lines.

"There are certain strategies one can employ," said Ponto. "A student who wishes to remain in the area may bid all his points on the local companies. On the other hand, the student may feel he can approach the local companies on his own for interviews and bid only on the out of state companies." Could a student list 1,000 companies at one point each and hope to gain more interviews? "Theoretically yes, practically no," said Ponto, "We don't really know what to expect yet, but we hope to see students obtaining four or five interviews with the companies they really want to see."

Although the system appears to be the most equitable, it has one disadvantage. Under this system, there will be a limit to the number of interviews a student can schedule; this number will be determined by the number of interview schedules available this year. Individual initiative will not gain a student anything. In the past, a student who was willing to come early could guarantee himself as many interviews as he wished. One student who graduated several years ago might be sorry to see the old system go—he had 62 interviews.

After the computer has assigned student interviews, there will be a three day sign-up period. The first-come, first-serve system will be used to schedule specific interview times and to fill late or incomplete schedules. Because the sign-up period has been reduced from the weekly sign-ups in the past to only once per quarter, it will be important for students to attend if they wish to secure additional interviews. Also, students should check the Placement Office frequently for additional schedules and interview information which will be posted during the quarter.

The Placement Office offers one of the best ways to contact companies, but a student need not restrict his job-hunting efforts to companies that will be recruiting on campus; from Abbott Labs to Zenith Corp., resources are available on a wide range of companies. Company profiles and corporate reports are on hand for student use during placement office hours (8-4:30 Mon. through Fri.). These materials can help the student prepare for a well-informed interview as well as provide excellent research information. In addition, literature on visiting companies is available to the students. However, this material disappears quickly from the shelves! For students wishing to contact companies by mail, a file listing company addresses is available. So you don't know exactly what a methods engineer does? The Placement Office has a booklet listing specific engineering job descriptions.

The Placement Office will present a series of seminars this fall on everything from interviewing techniques to writing a winning resume. These presentations will give the student an idea of what to expect this year and information on how the placement office can help in the job search. The fall seminar schedule will be available in the Placement Office the first week of fall quarter. If you are planning to interview through the Placement Office this year, packets will be available September 15 which will contain all registration information. While the I.T. Placement Office offers a tremendous amount of information to the student, it should be just one of many avenues in the job search. "The placement office is a good place to start," said Ponto, "but the student should supplement this with many other activities."

Finding a job may continue to be challenging, but an individual who is well prepared can increase his chances. "Our students are going to have to be more flexible this year," said Lee Ponto. Have clear and realistic goals, but remain open to alternatives. An early start will allow an individual more time to prepare and give him the opportunity to explore more areas in the job search.

Photo/Scott Dacko

Lee Ponto, Director of Student Affairs and Placement

Attitudes can play an important part. Be confident, be positive, above all, have a good time—interviewing can be fun! Hard work, perseverance and a little luck will help you find not just "a job" but the job that's right for you! ■

Karen Auguston is a mechanical/industrial engineering graduate of the University of Minnesota. Hoping to prepare students for the new computerized interviewing system, she has volunteered to take a small group of I.T. seniors to Monte Carlo.

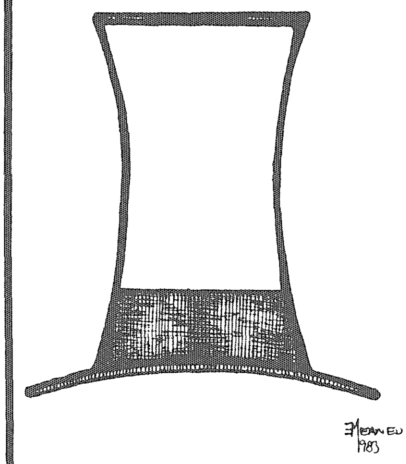
Dimensions from 11
analogies from a two dimensional plane to explain the third dimension to a character living on the plane. In *Flatland*, a sphere goes through a flat plane. At first the sphere intersects the plane at a point, but as the sphere passes through the plane the intersection of the two changes to a circle which at first slowly increases in size and later decreases in size. The three dimensional sphere is explained by a sequence of circles. Likewise, Banchoff's films use three dimensional images of four dimensional shapes, called projections, and shows them like a movie of three dimensional slices through a four dimensional object.

Banchoff claims to be able to see the fourth dimension. He does use more than just a *Flatland*-like film to see it. He uses one computer which helps him visualize two dimensional objects in four dimensions. "It's like walking through a house," he said. The computer is a device which enables him to see in less of a movie-like way and in more of a composite visualization of many two dimensional projections of the fourth. He puts the projections together mentally to "see" four dimensional shapes: "I will see a continuous family of views of it, that way I will be able to see it."

To those who doubt that the fourth dimension can be seen, Banchoff said, "These people have a different perception of what seeing the fourth dimension is; they want to see it all at once." He continued, "When you look at a two dimensional square, you can see it all at once. But when you look at a cube, you cannot see it all at once, yet you can see it. Likewise you cannot see a hypercube in four dimensions all at once, but you can see it. I feel that the way we see three dimensional objects is much the same as the way we see four dimensional ones."

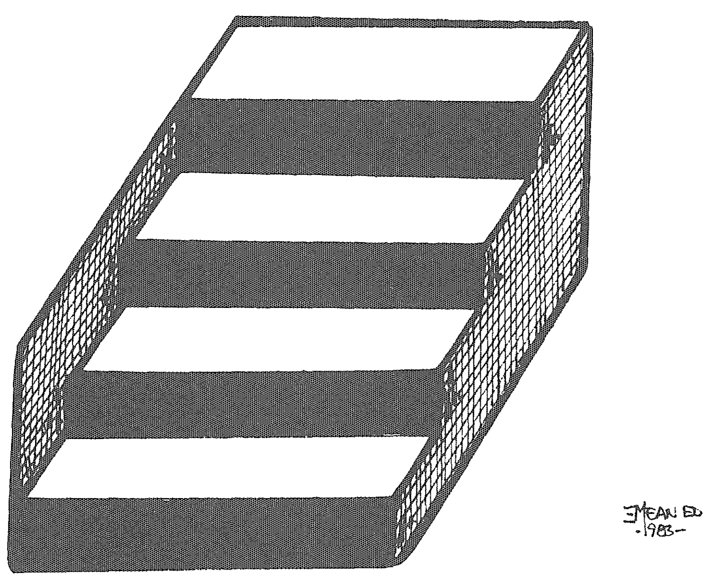
It may be the same, but it is moving from trying to visualize three dimensional objects to four dimensional shapes that incredible visionaries like Banchoff and Thurston are not the same as the common visionary.

For the simple, common, mortal man, there still is hope, even with wizards like Thurston and Banchoff running around. There are some old tricks and technology which caters to the basic three dimensional perceptions. Some computer viewers now shade images to add to the impression of depth. There is a new terminal in experimental use by Genisco, called the Spacegraph, which makes actual three



Is this top-hat taller than it is wide?

dimensional images by use of a vibrating mirror in the back of its screen. Among a host of other visual gadgets for the basic perceiver are three dimensional comic books, complete with colored glasses. The three dimensional comic books have been around about as long as geologists have used stereographs, devices used for seeing three dimensional images of rock photographs, and about as long as three dimensional movies, which were very popular in the past, when Alfred Hitchcock would direct Grace Kelly in the three dimensional *Dial M for Murder.* After a 23 year lull in the three dimensional movie business for major studios, last year's *Friday the 13th III,* this summer's *Space Hunter* and *Jaws III-D,* and this fall's *The Man Who Wasn't There,* have been the new space invaders in the big picture business. Speaking of space invaders, Atari has been doing research in hologram video games which given physical, three dimensional shapes to images. Also, three dimensional television is around the corner. Much, much more is waiting for the common visionary besides all that is already in sight. ■



A magic staircase! *One second the staircase appears to go up to the right, and the next it appears to be upside down.*

Mike Doran is a senior math major. Using his newly acquired ability to look into the fourth and fifth dimensions, he is now attempting to visualize a way to balance the *Technolog* budget.

I.T. Fall Recruiting Schedule

Note: As this schedule is subject to change, please confirm with I.T. placement office.

- **Monday, October 10**
  No Interviews

- **Tuesday, October 11**
  Amoco Research Center
  Battelle Northwest
  Exxon Corporation & U.S.A. Affiliates
  Frito-Lay Incorporated
  Gould Incorporated/Research & Development
  North Star Steel Company
  Quaker Oats Company

- **Wednesday, October 12**
  Amoco Research Center
  Battelle Northwest (2nd Day)
  Boeing Military Airplane Company
  Data General Corporation
  Exxon Corp. & U.S.A. Affiliates (2nd Day)
  NASA/Lewis Research Center
  Owens-Corning Fiberglass Technical Ctr.
  Union Carbide Corporation (PhD-ChemE)

- **Thursday, October 13**
  Boeing Military Airplane Company (2nd Day)
  Exxon Corp. & U.S.A. Affiliates (3rd Day)
  Interstate Power Company
  Kaiser Aluminum and Chemical Corporation
  Union Oil Company of California
  UOP Incorporated
  United Technologies/INMONT
  Raychem Corporation

- **Friday, October 14**
  Advanced Micro Devices Incorporated
  Archer Daniels Midland Company
  Johnson Controls Incorporated
  Raychem Corporation (2nd Day)
  Shell Development Company (PhD)
  Tektronix Incorporated
  Union Oil Company of California (2nd Day)
  United States Navy
  Wisconsin Power and Light Company

- **Monday, October 17**
  Applied Communications Incorporated
  Ethyl Corporation/Edwin Cooper Division
  General Mills Incorporated
  Hughes Aircraft Company
  Procter & Gamble Company (The)
  Sperry Defense Systems
  Sperry Product Division
  Trane Company (The)

- **Tuesday, October 18**
  Allen-Bradley Company
  Oscar Mayer Foods Corporation
  Procter & Gamble Company (The) (2nd Day)
  Sperry Defense Systems (2nd Day)
  Sperry Product Division (2nd Day)
  Sperry Semiconductor Division
  Texas Instruments Incorporated
  Trane Company (The) (2nd Day)

- **Wednesday, October 19**
  E. I. Du Pont
  General Mills Incorporated/James Ford Bell Technical Center
  Rohm and Haas Company
  Sperry Defense Systems (3rd Day)
  Standard Oil Company (Ohio) (The) (PhD)
  Texas Instruments Incorporated (2nd Day)
  Trane Company (The) (3rd Day)

- **Thursday, October 20**
  American Cyanamid Company
  Black & Veatch
  E. I. Du Pont (2nd Day)
  Eastman Kodak Company
  Stone & Webster Engineering Company
  Texas Instruments Incorporated (3rd Day)
  Trane Company (The) (4th Day)

- **Friday, October 21**
  American Electric Power Service Corp.
  Cargill Incorporated/Processing
  E. I. Du Pont (3rd Day)
  Northern States Power Company
  Rosemount Incorporated
  Trane Company (the) (5th Day)
  Wang Laboratories Incorporated
  Westvaco Corporation

- **Monday, October 24**
  Control Data Corporation
  Digital Equipment Corporation
  Kohler Company
  3M Company
  Mobil Oil Corporation
  National Security Agency
  Shell Development Company
- **Tuesday, October 25**
  General Dynamics Corporation
  McDonnell Douglas Corp. (2nd Day)
  3M Company (2nd Day)
  Peace Corps
  Schlumberger Well Services (2nd Day)
  Shell Oil Company (2nd Day)

- **Wednesday, October 26**
  General Dynamics Corporation (2nd Day)
  McDonnell Douglas Corp. (2nd Day)
  Schlumberger Well Services (2nd Day)
  Shell Oil Company (2nd Day)

- **Thursday, October 27**
  Chevron U.S.A. Incorporated
  Intel Corporation
  3M Company (3rd Day)
  Motorola Incorporated
  Northern Telecom Incorporated
  Standard Oil Company (Ohio) (The)

- **Friday, October 28**
  Chevron U.S.A. Incorporated (2nd Day)
  FMC Corporation
  Intel Corporation (2nd Day)
  3M Company (4th Day)
  Northern States Power Company (2nd visit)
  Standard Oil Company (Ohio) (The) (2nd Day)
  Sundstrand Corporation
  Dow Chemical U.S.A.-Marketing Division

- **Monday, October 31**
  No Interviews

  If you are interviewing with IBM please pick up your resume today.

- **Tuesday, November 1**
  No Interviews

  IBM Informational Meeting and sign-up in CMU.

  If you are interviewing with IBM please pick up your resume today.

- **Wednesday, November 2**
  Cray Research Incorporated
  Dow Chemical U.S.A.
  Honeywell Incorporated
  IBM Corporation (Interviews in CMU)
  Modine Manufacturing Company
  Naval Weapons Center
  Northern Indiana Public Service Company

- **Thursday, November 3**
  Beloit Corporation
  Dow Chemical U.S.A. (2nd Day)
  General Electric Company
  Honeywell Incorporated (2nd Day)
  IBM Corporation (2nd Day) (CMU)
  NASA/Geo. C. Marshall Space Flight Ctr.

- **Friday, November 4**
  Amoco Chemicals-Joliet
  Amoco Production Research
  Cray Research Incorporated (2nd visit)
  General Electric Company (2nd Day)
  Hercules Incorporated (PhD)
  Eastman Kodak Company (PhD-ChemE) (A.M.)
  Marquip Incorporated
  Procter & Gamble Company (The) (Mgmt. Sys.)
  Whirlpool Corporation

- **Monday, November 7**
  AMF Incorporated
  Boise Cascade Corporation
  Illinois Department of Transportation
  E. F. Johnson Company
  Monsanto Company
  Pacific Missile Test Center
  York Division/Borg-Warner Corporation
  Cargill Incorporated
  Applied Magnetics Corporation

- **Tuesday, November 8**
  Burroughs Corporation
  Eli Lilly and Company
  Firestone Tire & Rubber Company
  General Motors Corporation
  GTE Corporation
  Kimberly-Clark Corporation
  Monsanto Company (2nd Day)

- **Wednesday, November 9**
  Atlantic Richfield Company
  General Motors Corporation (2nd Day)
  GTE Corporation (2nd Day)
  Monsanto Company (3rd Day)

- **Thursday, November 10**
  General Electric Company (PhD)
  General Motors Corporation
  Monsanto Company (4th Day)
  United States Air Force

- **Friday, November 11**
  IXI Laboratories
  Northern States Power Co. (3rd visit)
  Pillsbury Company (The)
  United States Air Force (2nd Day)
  Chrysler Corporation
  Burlington Northern Incorporated
  Hutchinson Technology Incorporated

- **Monday, November 14**
  Beech Aircraft Corporation
  National Semiconductor Corporation (UT)
  National Semiconductor Corporation (CT)
  Union Carbide Corporation
  Warner Electric Brake & Clutch Company
  DARCOM

- **Tuesday, November 15**
  Hewlett-Packard Company
  Union Carbide Corporation (2nd Day)
  Pacific Gas & Electric Company

- **Wednesday, November 16**
  Albany International
  Hewlett-Packard Company (2nd Day)
  Northrop Corporation
  Upjohn Company (The)
  Radio Corporation of America
  Onyx Systems Incorporated

- **Thursday, November 17**
  NCR Comten Incorporated
  PM Incorporated
  Rockwell International
  Air Products and Chemicals Incorporated
  Dow Corning Corporation
  Verbatim Corporation

- **Friday, November 18**
  ADC Magnetic Controls Company
  Inland Steel Company
  PM Incorporated (2nd Day)
  Rockwell International (2nd Day)
  Dow Corning Corporation (2nd Day)
  Western Electric Company (PhD)

- **Monday, November 21**
  Champion International Corporation

Continued on page 36

Ad Astra

By Scott Otterson

*Minnesota Technolog has resurrected the **"Ad Astra"** column and placed it under the skillful guidance of **Scott Otterson.** Each issue both science fiction and science fact books will be reviewed.*

Millennium, John Varley, A Berkley Book, paperback, 247 pages, $6.95
Orion Shall Rise, Poul Anderson, Simon and Schuster, paperback, 463 pages, $7.95
The Turning Point, Fritjoff Capra, Bantam Books, paperback, 419 pages, $8.95

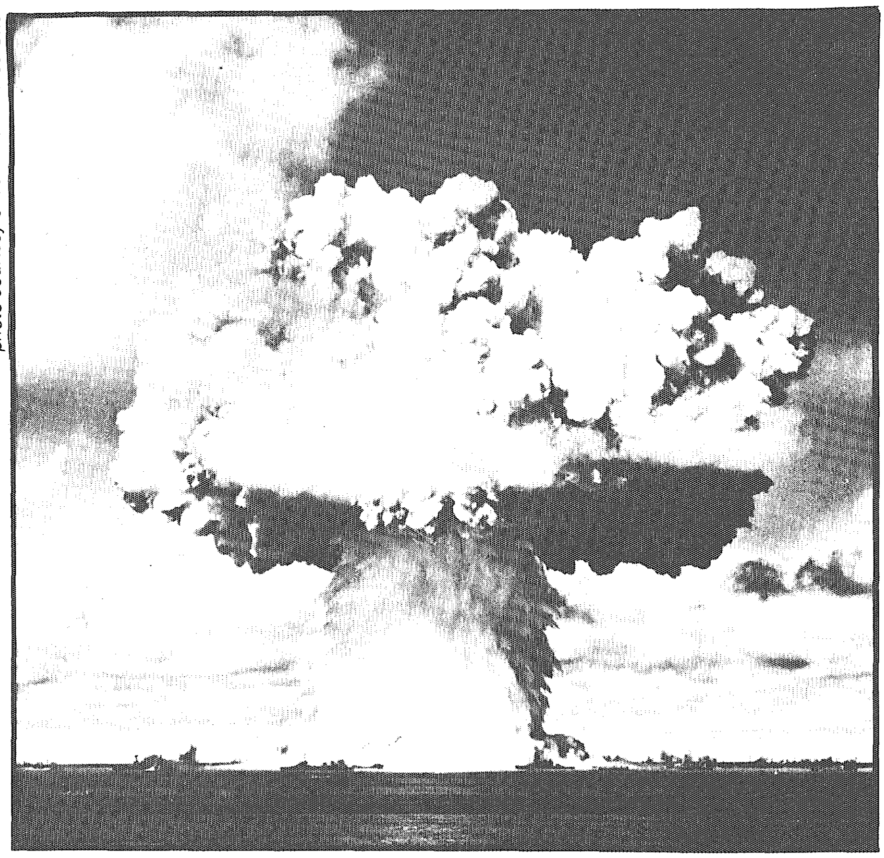


photo courtesy of Joint Task Force One

***Orion Shall Rise, The Turning Point,** and **Millennium** are concerned with the nuclear menace.*

Time travel is one of those physically unlikely concepts that has been used by so many authors in so many books that, like teleportation and intergalactic space travel, it has become a venerable institution, as familiar and common place in the world of science fiction as the laws of gravity. ***Millennium,*** with chapter titles mostly borrowed from time travel stories written in the Golden Age of science fiction, is a tribute to its predecessors. But rather than play with the paradoxes of time travel (like the possibility of becoming one's own grandfather) as the Golden Age authors did, **John Varley** constructs his story around his characters and the flow of history. The main idea in the book is not time travel itself, but the consequences of what we do today for future generations.

The world of Louise Baltimore has been horribly twisted by her ancestors. Centuries of biological, chemical, and nuclear warfare have devastated the Earth to the point where the only living things that survive in the chemical stench and radioactive ash are fiendishly mutated bacteria, insects, and the last wretched generation of Homo sapiens. With an average life expectancy of about thirty years and with a sort of genetic leprosy that makes artificial limbs a universal necessity, eventually turning people into talking heads on mechanical pedestals, humanity has little future. But a few of those who are not mindless from despair or dead from suicide are desperately trying to make a new future for their race. Louise is the no-nonsense leader of a "snatch team" which uses a time gate to remove 20th century airline passengers from planes that will crash with one-hundred percent fatality. The passengers are put in cold storage for future transfer to a new planet, and in their seats are put pre-burned and mangled replicas. But time is running out as a hand weapon accidentally left on a crashing jet threatens to raise 20th century suspicions, wrecking the Gate Project and maybe more.

On the other side of the time gate, in the 1980s, is Bill Smith, an alcoholic air disaster investigator on his way down. Louise's job is to prevent his discovery of the weapon by distracting him on the day the gate predicts he will find it in the crash debris. Bill is divorced and lonely, looking at life with a deep pessimism matched only by Louise's. It doesn't take the reader long to guess who is going to fall in love with whom. The twist in the plot comes when a second weapon surfaces.

But the real message of *Millennium* is not so much in the story as in the way the story is told. Varley's narration and characters are relentlessly bitter, sarcastic, and cynical. His unwavering emphasis on the mutated and decaying bodies in the future and the "burned meat" of the present is coupled with acid commentary from both main characters. The effect on the reader is one of suspended queasiness, a fear and disgust of what technology can do to man, or rather, what man can let technology do to himself, for Varley does not dismiss our cooperation. Louise puts the blame for her wretched world squarely on our backs.

"It started with your great-grandfather and the industrial revolution. But it was you, *your ——ing generation that really got things going. Did you really think there'd never be a nuclear war? There have been nineteen of them. Did you really think that the nerve gases were going to sit there, that nobody would ever use them?"*

In the final analysis, *Millennium* is less a tribute to science fiction of the past than a warning of an all too possible reality in the future.

Although it too has seen nuclear devastation, the world that author **Poul Anderson** maps out in ***Orion Shall Rise*** is not yet dying. But it is in danger of doing so.

The time is centuries after Judgement, the awful age when irresponsible plundering of natural resources and nuclear war nearly wiped out the old civilizations of our era. There are now three dominant cultures: the Domain, a feudal society ruled by the Aerogens, a class that controls the immense dirigible positioned in the stratosphere above what was once western Europe; the Maurai, a seafaring, ecologically fanatic federation of Pacific islands, New Zealand, and Australia; and the Northwestern Union, a freewheeling, coal-smoke belching nation of individualists running along the Pacific coast of North America from old Oregon to "Laska." Contending with these three power centers are the Mong, a clan of Asians who seem to be located in the old communist countries and North America, east of the Rockies.

Although the Mong are considered ignorant barbarians by the big three, the Buddhism-like Mong philosophy/religion called Gaenity has spread through the Domain, eroding traditional aristocratic support of the Aerogens. A Gaen-converted noble stages a military coup and deprives young Talence Iern Ferlay of his heritage as captain of the dirigible. Iern escapes, and with the help of Plik, the drunken poet, he goes underground.

Across the Atlantic, the Northwestern Union chafes under Maurai chains. A generation ago the energy hungry Norries tried to rekindle the nuclear fire. Ensuing war with the horrified Maurai has left them an occupied nation. Ronica Birken is a Norrie engineer and covert prospector of ancient unexploded nuclear warheads. With the salvaged fissionables the Union intends to launch nuclear powered spaceships which will end Maurai domination and open up the Earth to exploitation and high energy industrialization as in pre-Judgment days. The "Orion Project" is headed by the brilliant but nihilistic Mikli Karst. His counterpart is Maurai spy Terai Lohannaso.

As a result of political intrigue, the protagonists find themselves alternately allied and oposed in a life or death struggle that will either end in Earth's reincineration or will forge a new social order different from anything that has preceded it.

Orion Shall Rise is an immensely satisfying book. It has action, suspense, and intricate plotting. Its science and technology are believable, and most importantly, it does not shun political and ideological complexity. As in the real world, there is no black or white. Each society has strengths and limitations. I found myself constantly shifting sympathies between the medieval stewardship of the Aerogens, and responsible Maurai ecological hegemony, the mystical, earth-loving Gaen Mongs, and the good old don't-tread-on-me Northwestern self-reliance.

A minor complaint: Even though Anderson's politics are complex, his characters sometimes are not. Instead of responding to situations with subtlety, they are prone to teeth clenching, dropping things in surprise, "roaring like thunder," and other exaggerated visceral reactions. But this is only a minor complaint. The characters are still believable though a little transparent at times.

Almost incidentally, *Orion Shall Rise* is also a fascinating puzzle. Over the centuries the old geographical names have mutated to near obscurity which can make placing locales challenging. For example, Europe is Yirrup, Uropa, or Yevropea, depending upon who's doing the talking. And where the heck is Kemper? The game gets really interesting when the protagonists trek across Mong territory along the greatest lake of all to the Gaen mecca of Dulua which is near the ancient open pit iron mine at I-Ping. And the next time I head west on Highway 7, I'll be tempted to look for the future site of the Northwestern Union's Yuanese embassy—some place called Minyatonka.

According to **Fritjoff Capra**, author of ***The Turning Point*** and high energy particle physicist, the same understanding of modern physics which creates the possibility of our nuclear extinction can equally serve as the foundation of a new world view portending a sane, sensible future. Capra believes that the Western way of interpreting aspects of reality as deep and as diverse as economics, medicine, and the mind has been patterned rigidly after early scientific explanations of the physical world known as Newtonian physics. Newton postulated that all matter can be described in terms of distinct material objects moving in absolute time and space, interacting mechanically with each other in deterministic patterns shaped by fundamental laws and forces. His theories were a great success, and leading thinkers in other fields emulated his approach. They looked for simple action and equal and opposite reaction between discrete components, ostensibly the building blocks of the complex behavior of living systems. They found what they were looking for. Louis Pasteur discovered his "one germ one illness" theory; Freud, the equilibrium of ego and id; Adam Smith, supply and demand; and the framers of the U.S. Constitution, the "balance of powers." The list goes on.

Today, life and social scientists regard these undeniably great pioneers with as much respect as modern physicists regard Newton. The difference, however, is that modern physicists have moved on. Their new models of reality "knock common sense on its ear." Space and time are relative, light behaves paradoxically as both particle and wave, and cause, effect, and objectivity are artificial, man-imposed concepts. According to Capra the rest of the West has failed to take the hint. He contends that our present world view is still Newtonian, that it is an inadequate framework for explaining and guiding living beings just as it is inaccurate as a description of the atom.

Capra lists the effects of our dependence on the Newtonian paradigm: Mental illness and violent crime are on the increase, the result of ineffective psychology, social inequities, poor ethical education, and a stagnant economy. Pollution, both chemical and nuclear, poisons the biosphere. In spite of tremendous biomedical advances, we are not appreciably more healthy than our ancestors. (I was skeptical but Capra has convincing arguments to back this one up.) And the experts are bewildered. Doctors are stumped on cancer (which is more prevalent than it used to be), our socially engineered prisons don't work, and economists from Reaganite Milton Friedman to former Carter Secretary of Commerce Juanita Kreps admit that economic theories are at best naive. The only consolation, say some pessimists, is that the military-industrial complex will solve our problems by blasting us all out of existence.

> *"Living systems are organized in such a way that they form multi-leveled structures, each level consisting of subsystems which are wholes in regard to their counterparts, and parts with respect to larger wholes. Thus molecules combine to form organelles, which in turn combine to form cells.... These, finally, combine to form the living woman or man; and the "stratified order" does not end there. People form families, tribes, societies, nations. All these entities—from molecules to human beings, and on to social systems—can be regarded as wholes in the sense of being integrated structures, and also as parts of larger wholes at higher levels of complexity. In fact, we shall see that parts and wholes in an absolute sense do not exist at all."*

Excerpt from *The Turning Point*

Okay. Okay. Our society isn't exactly perfect but does anybody have any better ideas? The solutions that Capra offers, what he believes to be the logical—indeed the unavoidable—implications of modern physics and historical inertia, must be read with an open mind. Now that may sound euphemistic, like "Runs good. Needs some work," but much of what Capra has to say makes sense.

Briefly, he advocates a "systems view" of the world, a perspective in which the reductionist metaphor of the universe as machine is invalid, where reality is more than the sum of its parts, and where the belief that the actions of one part affect all others leads to a more ecological, socialistic, and feminist approach. We are all one with the universe and in that light the arbitrary divisions that isolate mind from body from environment and which make for cut-throat competition, rampant economic growth, and war are seen as harmful to all concerned. This new world view has a lot in common with Buddhism, which is not surprising since Capra's first book, *The Tao of Physics*, argued the connection between Eastern religion and modern physics.

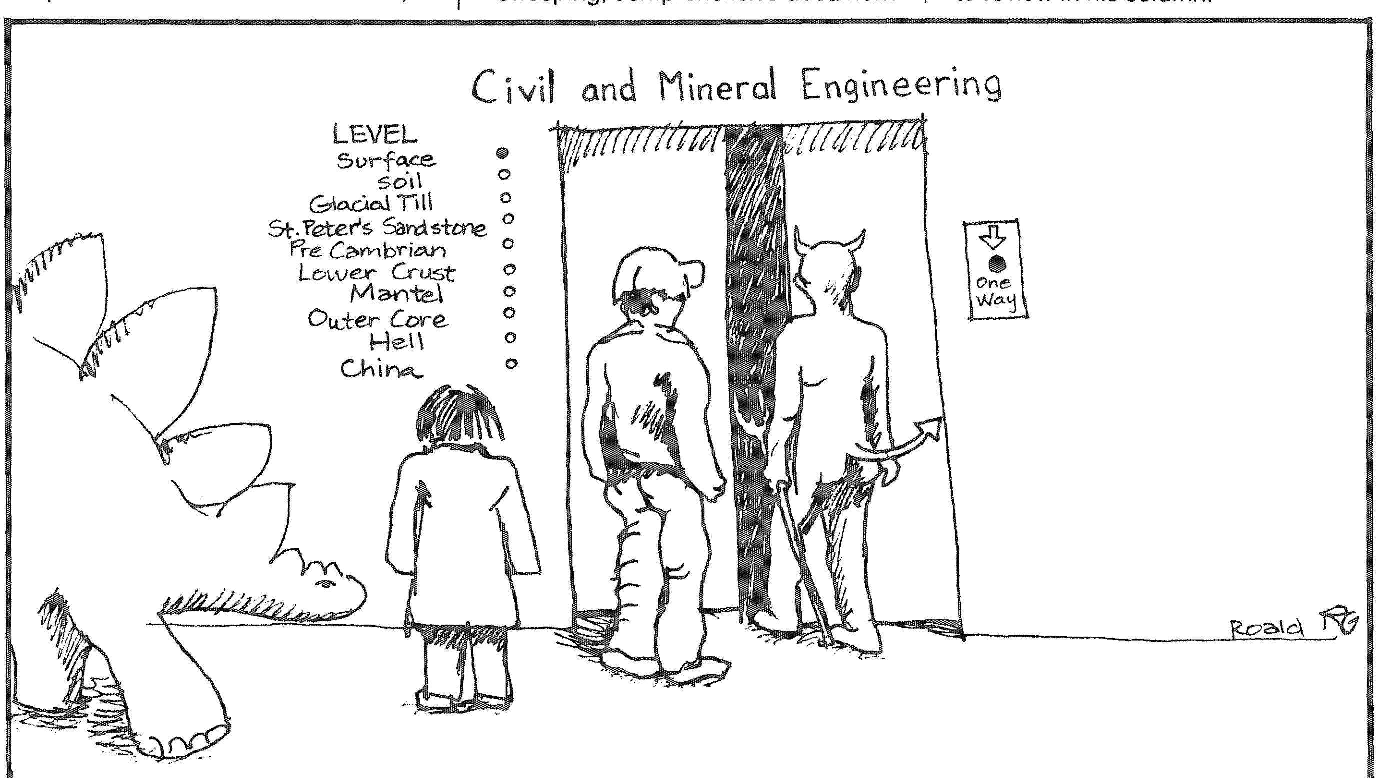
Unfortunately, Capra's embrace of Buddhism sometimes taints his arguments. His support of herbal medicine and massage therapies that rechannel "subtle bioenergies" has the aura of the hokum found in *City Pages* classifieds. These fringe groups may be compatible with Eastern religions, but no hard evidence of their compatibility with modern physics or any science is presented. One suspects that Capra traveled from modern physics to Buddhism and then brought some extra baggage from the East back.

Capra, of course, would say that objections such as these are to be expected from a narrow Newtonian, but there are other problems with some of his recommendations. One is that he occasionally misrepresents present Newtonian thought, identifying obsolete, overly simple theories such as classical Darwinism as Newtonian while scientists using the Newtonian method have since advanced to theories he identifies as belonging to the systems view. Another is that he doesn't always give evidence that the Newtonian outlook is the root cause of our befuddlement or that the systems view would make things any clearer. Instead, he assumes this, *ipso facto*. For example: "... since most researchers still operate within the [Newtonian] framework, they will find the phenomenon of cancer extremely bewildering." Who says? Who really knows what the causes of cancer are, and who can tell what approach will lead to its understanding? Finally, societies that have adopted some aspects of the systems view haven't demonstrated that they necessarily fare any better than we do. Witness the turmoil and poverty of mystical India and the spotty economic record—with the notable exception of Norway—of the socialist countries.

Nevertheless, the book is *definitely* worth reading. If nothing else, *The Turning Point*, is a sweeping, comprehensive document of Newtonian science's influence on Western thinking. It is more than that. Despite its weaknesses, it provides a sensible and compelling argument for humane health care, solar power, more decentralized and environmentally conscious industry, and an economic theory that takes human values into account. I particularly liked the suggestion that governmental reports on industrial efficiency be made in terms of net energy consumption.

Regardless of whether you accept the notion that modern physics implies any world view whatsoever, there is an inevitability about Western acceptance of most of the systems view. Assuming that we don't blow ourselves up first—and perhaps after we do—exhausted natural resources and intolerable pollution will eventually force us to adopt a new paradigm. It is only a question of time and method. Either we wait until circumstances wrench the transition or we heed sane arguments like those offered in *The Turning Point.* ■

Scott Otterson is a senior in electrical engineering when he is not roaming the galaxy in search of literary works to review in his column.



Technotrivia ???

By Nicholas W. Pilugin
Al Hauser

Are you a science trivia whiz? Try your hand at these challenging trivia questions.

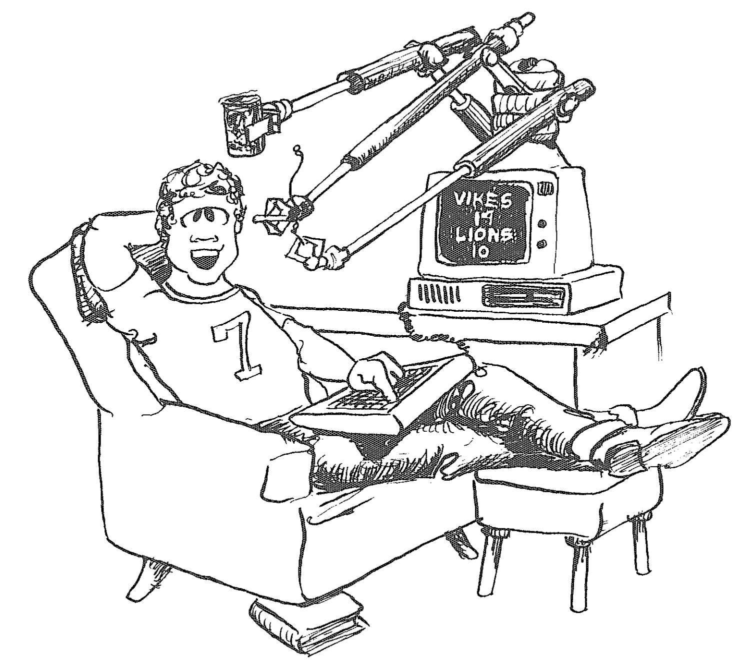
1. Who was the first scientist to propose a "wave theory" of light?

2. On the eve of detonating the first atomic bomb at the Trinity Test Site, scientists working on the project were not sure of all the possible consequences that might result from the test. Some of them made wagers on the chances of what effect occurring?

3. What American-born physicist of the revolutionary war era carried out investigations in thermodynamics, was instrumental in establishing heat as resulting from work, and was forced to quickly leave the colonies to avoid being tarred and feathered?

4. As the legend goes, Sir Isaac Newton discovered gravity when an apple fell on his head as he sat under a tree one day. Why was Newton goofing-off in the country instead of being hard at work in London?

5. In 1543 Copernicus published *On the Revolutions of the Heavenly Spheres,* a scientific treatise which maintained that the sun was the center of the solar system rather than the earth. Because of this Copernicus is often called the father of the heliocentric theory.



'NOW THIS IS WHAT I CALL USER FRIENDLY.'

Yet eighteen centuries earlier a Greek astronomer had proposed the same theory. What was his name?

What Is Carl Sagan's Favorite Number?

6. In 1949 three Americans by the name Shockley, Brattain, and Bardeen invented something that would completely change our way of life in only 30 years. What did they invent?

7. The early Greeks, such as Aristotle, believed that all matter was composed of four elements. What were these elements?

8. A greenish-glow associated with nuclear reactors when the reactor core is immersed in a pool of water is called "Cherenkov Radiation." What causes this eerie glow?

9. In 2136 B.C., two Chinese scientists were put to death for failing to carry out their duties. What had they neglected to do, and what were their names?

10. Finally, a Carl Sagan trivia question: How many galaxies are there in the universe?

Trivia answers on page 36

Technotrivia Answers

1. Christian Huygens (1629-1695) proposed a wave theory of light in the 17th century. His view, however, did not gain general acceptance until after 1800. Before that time Isaac Newton's "corpusculor" theory was more influential. Now it is known that these theories are not mutually exclusive. Source: Holmes Boynton, The Beginnings of Modern Science, 1948, p. 136.

2. There was some concern that the earth's atmosphere might ignite from the blast.

3. Benjamin Thompson, who later became Count Rumford, was accused of being a British spy. He abandoned his wife and daughter when he fled.

4. Newton had fled London to avoid the latest plague and while at the estate of his mother realized gravity and, among other things, laid the foundations of calculus.

5. Aristarchus of Samos advocated the idea of a sun-centered solar system during the 2nd century B.C. He also devised a method of calculating the distance between the earth and the sun which was used well into the Middle Ages. Source: Arthur Koestler, The Sleepwalkers, 1963, Chapt. 3.

6. Shockley, Brattain and Bardeen, all of the Bell Telephone Laboratories, made the computer revolution of today possible by inventing the transistor. They were awarded the Nobel prize in 1956 for their efforts.

7. The four elements were earth, water, air, and fire. Each element, it was believed, moved in a straight line: air and water horizontally, earth downward, and fire upward.

8. The velocity of the high-energy particles traveling through the water is greater than that of light in the medium. The glow is a "light wake."

9. The two, court astronomers Hsi and Ho, had failed to predict a solar eclipse.

10. Approximately a hundred billion (10^{11}) galaxies exist, each of which contains, on the average, a hundred billion stars (give or take a billion). Source: Carl Sagan, Cosmos, 1980, p. 5.

Score

0-1 You'll probably get a job designing paperweights.

2-3 You've been spending too much time playing video games.

4-6 Hey, you're pretty good!

7-8 Peeking at the answers is not acceptable.

9-10 You should be working for *Technolog*.

Recruiting from 30

- **Tuesday, November 22**
  Champion International Corp. (2nd Day)

- **Wednesday, November 23**
  No Interviews

- **Thursday, November 24**
  Thanksgiving Holiday

- **Friday, November 25**
  Thanksgiving Holiday

- **Monday, November 28**
  Central Intelligence Agency

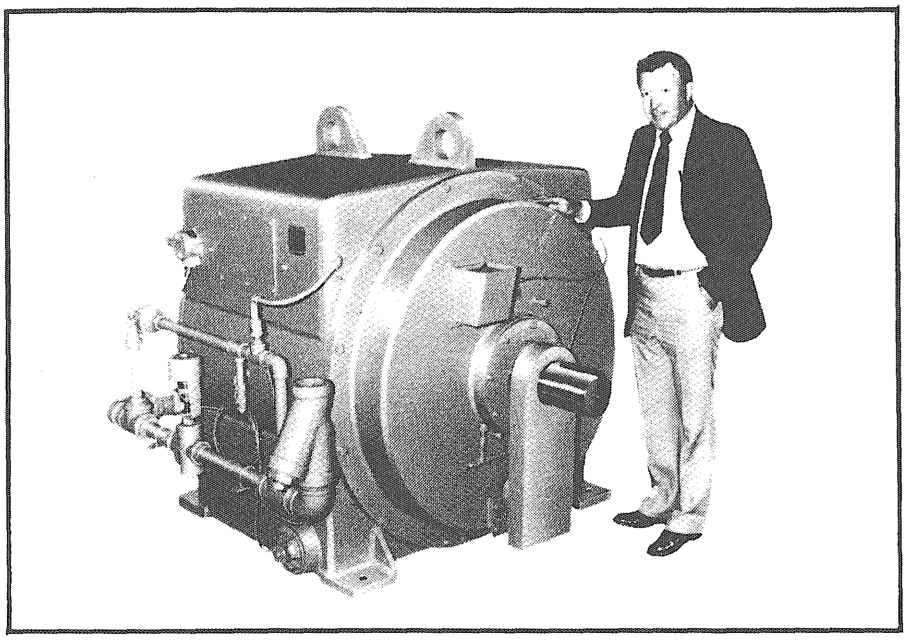
- **Tuesday, November 29**
  Central Intelligence Agency (2nd Day)
  Xerox Corporation (PhD)
  Amoco Oil, RT&E

- **Wednesday, November 30**
  Harris Corporation
  Bell Labs
  Sandia Labs (MS)
  Teletype Corporation
  Western Electric Company
  Carrier Corporation

- **Thursday, December 1**
  United States Navy (2nd visit)
  Bell Labs (2nd Day)
  Sandia Labs (MS) (2nd Day)
  Teletype Corporation (2nd Day)
  Western Electric Company (2nd Day)

- **Friday, December 2**
  United States Navy (2nd Day)
  Bell Labs (3rd Day)
  Sandia Labs (MS) (3rd Day)
  Teletype Corporation (3rd Day)
  Western Electric Company (3rd Day)

Mechanical engineer Fred Dweedle and his new invention: "It won't do anything, but it's big and I have a patent."



TechnoFlog

A student was perched outside a third story window of the E.E. building. A fellow student made his way out to persuade him not to jump.

"Think of your mother and family."

"Don't have any."

"Well, think of your girlfriend."

"She hates me."

"Life is so beautiful, why would you want to end it?"

"I only got a 93 on my E.E. 3010 test."

"Jump, you damn curve wrecker!"

A mechanical engineering student was having trouble with his parakeet. Every afternoon when he came home from classes, the bird would fly up on his shoulder and pick holes in his shirt. After thoughtful deliberation the student decided that the only solution was to file off the bird's beak. So he went to the M.E. tool crib to get a file.

When the tool crib supervisor found out why the student wanted the file, he tried talking him out of it, explaining that the parakeet could not eat without his beak. But it was all to no avail, so he reluctantly loaned him a file. A few weeks later the student was back in the tool crib, and the supervisor recognized him.

"How's your parakeet?" asked the supervisor.

"Oh, he's dead," the student replied.

"See, I told you so! I knew that your bird would die because he couldn't eat with his beak filed off!"

"Yeah," replied the student, "but I think he was dead when I took his head out of the vise."

Death to Curve Wreckers!

Did you hear about the civil engineering student who refuses to take a drink? You have to hand it to him.

Two forestry students were flying their plane up to a logging camp in northern Minnesota when the plane developed engine trouble,and the two were forced to bail out. The first student pulled his rip cord and began to float slowly towards the ground. Meanwhile the second student pulled his rip cord, but nothing happened. He then pulled his safety cord, and again nothing happened. The first student, seeing his friend shoot by at breakneck speed, unhooked his parachute and yelled, "So ya wanna race, huh?"

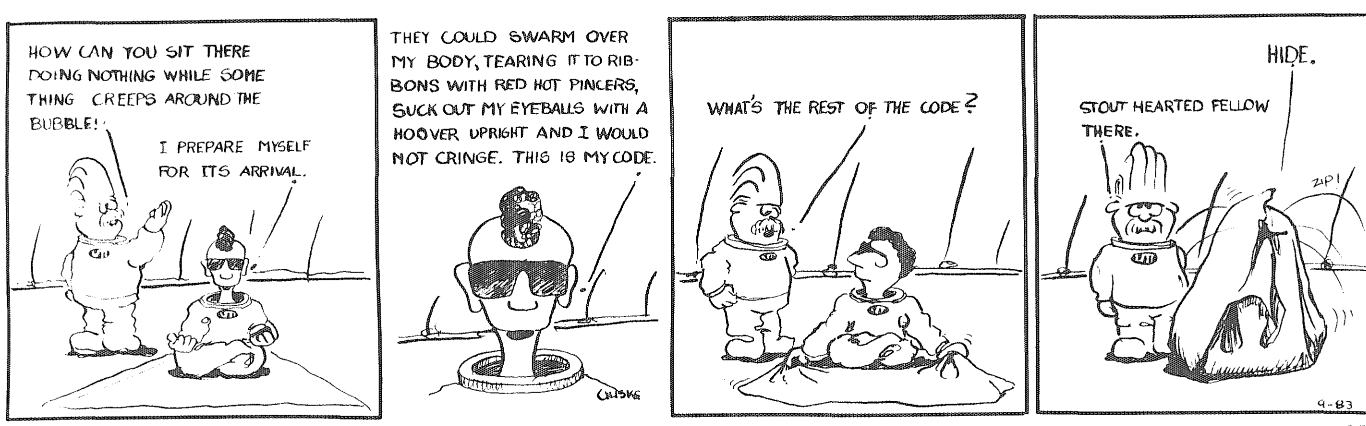
EE Lab Ballad

Through the smoke and ozone fumes
The student slowly rises.
His hair is singed, his face is black,
His partner he despises.
He shakes his head and says to him
In words so softly spoken,
"The last thing that you said to me
Was 'Sure, the switch is open.'"

from the ***Purdue Engineer Magazine***

BEBOX

By Scott Ciliske



Technopuzzle

By Drift Wood
Mark "Dr. Death" Stolzenburg
Al Hauser

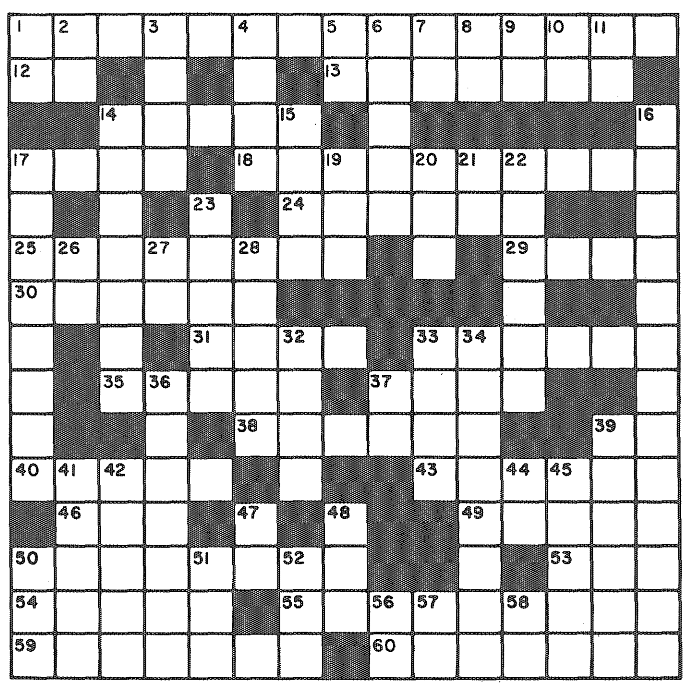
What's a Technopuzzle? A Technopuzzle is a crossword puzzle composed of technical words. Impress your friends by showing off your large, technical vocabulary. Impress the Technolog staff by being the first person to bring a correctly completed Technopuzzle to Room 2, Mechanical Engineering, and we'll give you a free "Do I.T. with an Engineer" T-shirt. Best of luck!

ACROSS

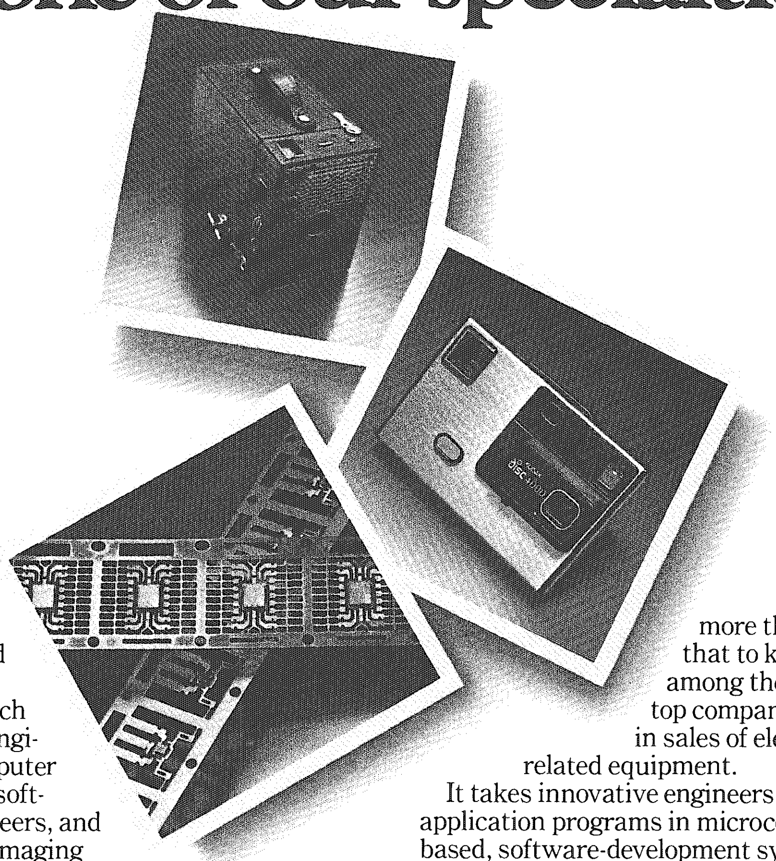
1. the process which yields the mathematical derivative
12. electrical engineering (abbr.)
13. electrical potential
14. an example of a subatomic particle
17. The product of the electric field strength and the area of a surface perpendicular to the field is called the electric ________ of the field through the surface.
18. characteristic value
24. the rain cloud that is of uniform grayness and extends over the entire sky
25. perhaps the most famous physicist of all time
29. unit of time
30. Heat given off or stored in a process other than temperature change is called ________ heat.
31. state where Orville Wright was born (abbr.)
33. not transparent
35. a device which is like a laser except that emitted radiation is in the microwave range
37. one of two or more regions in a magnetized body at which the magnetic flux density is concentrated
38. to turn on an axis
39. state where Edwin Drake drilled the first oil well (abbr.)
40. a unit of luminous flux
43. ________ Ibele, mechanical engineering professor
46. an imaginary circle on the surface of the earth passing through the poles (abbr.)
49. a luminous disruptive electrical discharge of a very short duration
50. When one uses degrees Kelvin, one is using the ________ temperature scale.
53. Texas Instruments is a large corporation. Therefore your TI calculator is actually a ________
54. In the movie "Star Wars," a robot was called a ________
55. coefficient of thermal ________
59. unit of luminous intensity
60. the electron emitting electrode in an electron tube

DOWN

1. differential equation (abbr.)
2. industrial engineer (abbr.)
3. the magnetic counterpart of 17 across
4. Any of a group of similar oxides of metals is called ________ earth.
5. 36th state admitted to the union (abbr.)
6. A type of pole which is neither positive nor negative
7. state in which first self-sustaining nuclear chain reaction occurred (abbr.)
8. example of a preposition
9. the guy who grades your homework and tests
10. immunoglobulin (abbr.)
11. Old English (abbr.)
14. ________ mechanics
15. Early hydrogen bomb testing occurred at Bi ______ Atoll.
16. (degree Fahrenheit)+459.67= ________ ________
17. a cell that changes the chemical energy of a fuel and oxidant to electrical energy (easy one!)
19. After a hard exam an I.T. student goes to the bar and has seven or eight ______ and tonics.
20. National Basketball Association (abbr.)
21. volume unit (abbr.)
22. an engineering society which is concerned with refrigeration, heating and air conditioning (abbr.)
23. atomic numbers (abbr.)
24. nickel (symbol)
26. a state that is named after an Indian word which means "one who puts to sleep" (the name fits!) (abbr.)
27. not south and not east, but ________ (abbr.)
28. formerly thought to be a medium for electromagnetic radiation
32. FE
33. a commonly used phrase which appears in the second to the last paragraph in John McGarthwaite's Solaron article (abbr.)
34. name of a street which runs by Smith Hall
36. containing no liquid, e.g. ________ manometer
37. the person who pays your tuition if you can't find a job
39. the reciprocal of frequency
41. the conical part of the shadow of a celestial body excluding all light from the primary source
42. an unstable, strongly interacting nuclear particle that has a mass between that of a proton and an electron
44. regular polygon (abbr.)
45. The ________ of the lengths of corresponding sides of triangles are equal if the triangles are similar triangles.
47. Indiana University (abbr.)
48. the nickname of your lab partner from Texas
50. analog/digital converter (abbr.)
51. same as 1 down but more specific (abbr.)
52. what students drink to stay awake when studying for an exam
56. reckoned on the basis of a whole divided into one hundred parts (abbr.)
57. a group you might join if you drink too much of 19 down (abbr.)
58. the oldest of the University dormitories (abbr.)



Electronics at Kodak. Putting good things in small packages is one of our specialties.



Kodak has entered a new era. One in which electrical engineers, computer scientists, software engineers, and electronic-imaging specialists interface to expand our considerable expertise in a wide variety of technologies.

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It takes innovative engineers to debug application programs in microcomputer-based, software-development systems. And skilled electronic-imaging professionals to design digital and analog signal-processing devices, and develop software for complex electromechanical hardware.

If you're interested in the challenge, diversity, and career advancement you'll find at Kodak, see a recruiter on campus. Or send your resume to:
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An equal opportunity employer manufacturing photographic products, fibers, plastics, chemicals, and electronic equipment. Plants in Rochester, N.Y.; Kingsport, Tenn.; Windsor, Colo.; Longview, Tex.; Columbia, S.C.; Batesville, Ark.; and a sales force all over the U.S.

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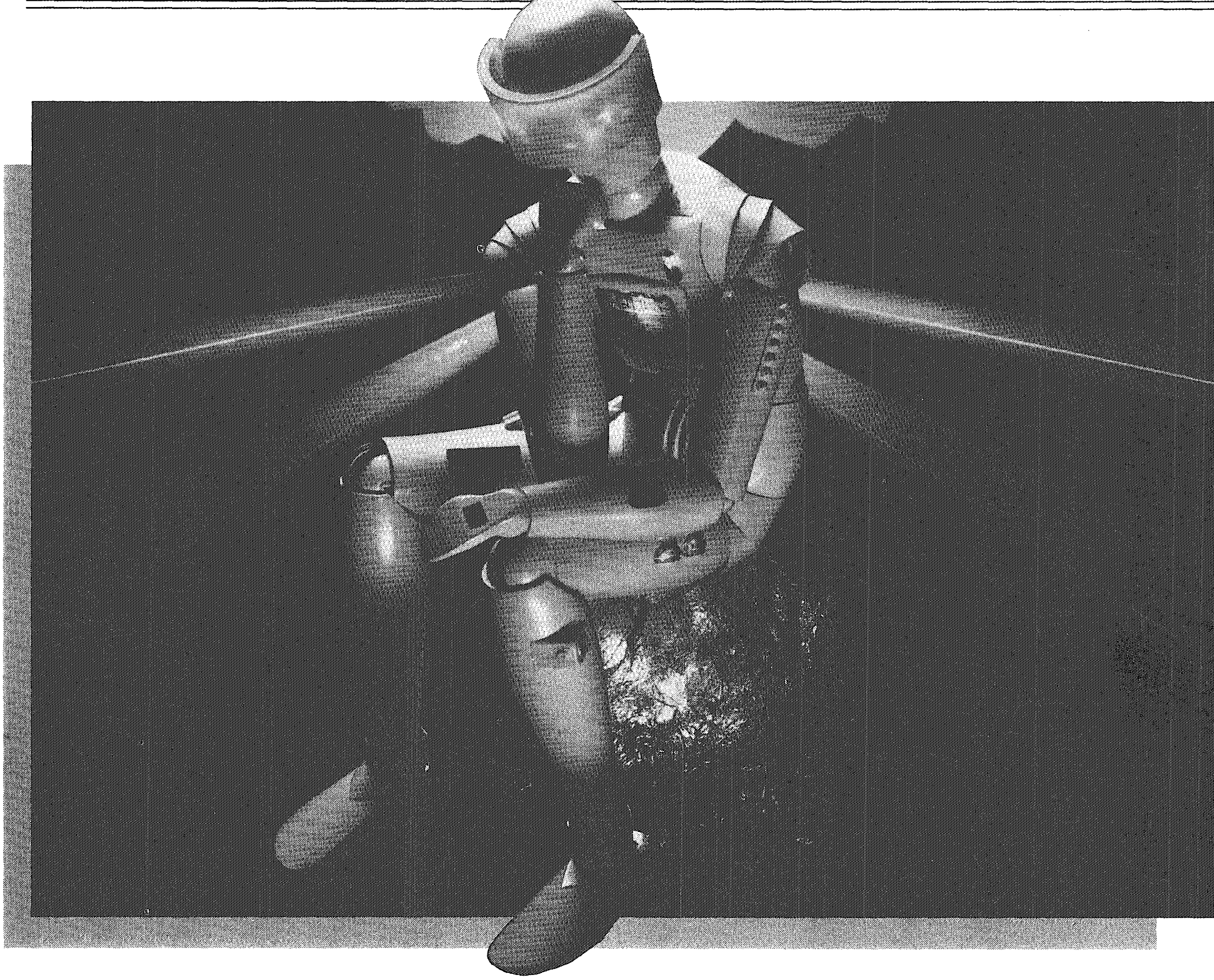


Create computers that capture the mysteries of common sense.

The brain does it naturally. It wonders. It thinks with spontaneity–advantages we haven't been able to give computers. We've made them "smart," able to make sophisticated calculations at very fast speeds. But we have yet to get them to act with insight, instinct, and intuition.

But what if we could devise ways to probe into the inner nature of human thought? So computers could follow the same rationale and reach the same conclusions a person would.

What if we could actually design computers to capture the mysteries of common sense?

At GE, we've already begun to implement advances in knowledge engineering. We are codifying the knowledge, intuition and experience of expert engineers and technicians into computer algorithms for diagnostic troubleshooting. At present, we are applying this breakthrough to diesel electric locomotive systems to reduce the number of engine teardowns for factory repair as well as adapting this technology to affect savings in other areas of manufacturing.

We are also looking at parallel processing, a method that divides problems into parts and attacks them simultaneously, rather than sequentially, the way the human brain might.

While extending technology and application of computer systems is important, the real excitement and the challenge of knowledge engineering is its conception. At the heart of all expert systems are master engineers and technicians, preserving their knowledge and experience, questioning their logic and dissecting their dreams. As one young employee said, "At GE, we're not just shaping machines and technology. We're shaping opportunity."

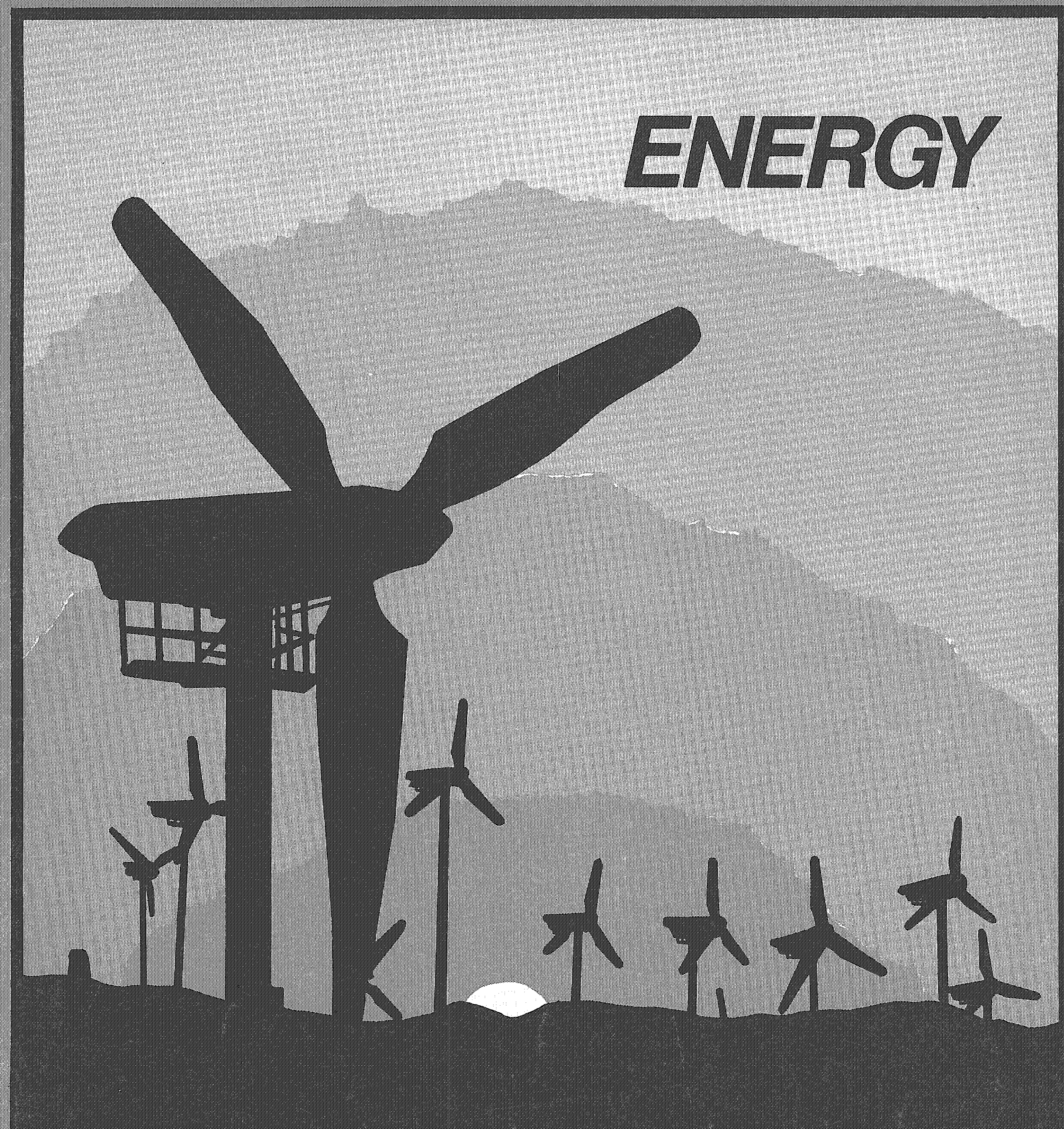
Thinking about the possibilities is the first step to making things happen. And it all starts with an eagerness to dream, a willingness to dare and the determination to make visions, reality.

An equal opportunity employer

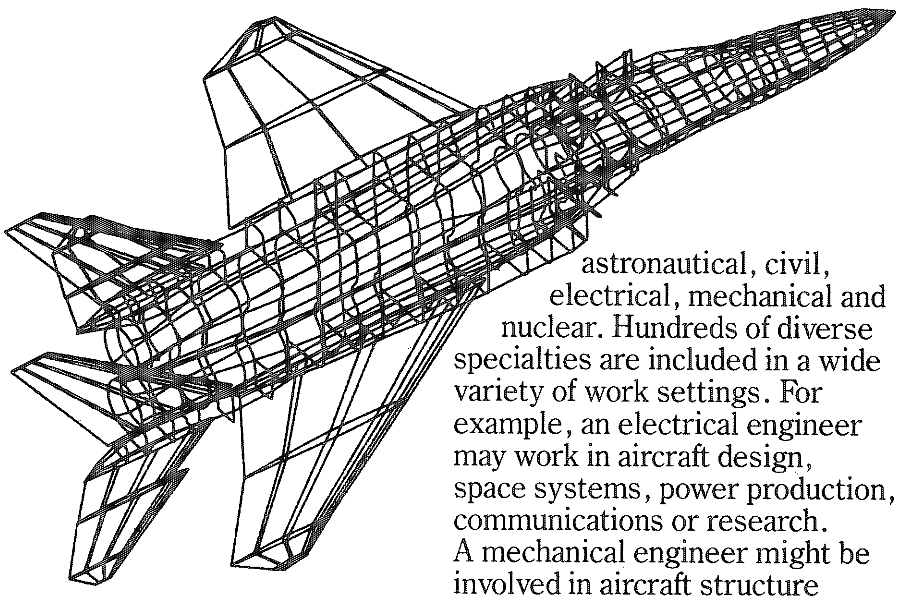
If you can dream it, you can do it.

minnesota

TECHNOLOG



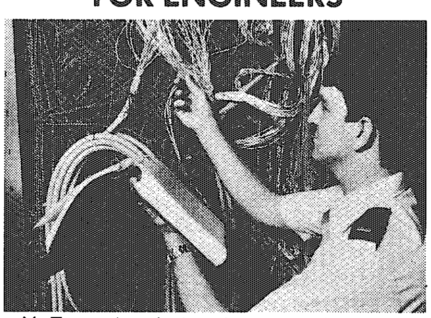
ENGINEERING TAKES ON EXCITING NEW DIMENSIONS IN THE AIR FORCE.



Computer-generated design for investigating structural strengths and weaknesses.

Developing and managing Air Force engineering projects could be the most important, exciting challenge of your life. The projects extend to virtually every engineering frontier.

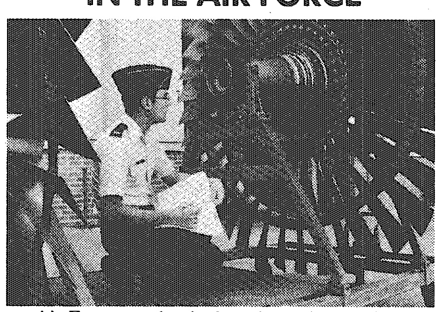
8 CAREER FIELDS FOR ENGINEERS



Air Force electrical engineer studying aircraft electrical power supply system.

Engineering opportunities in the Air Force include these eight career areas: aeronautical, aerospace, architectural, astronautical, civil, electrical, mechanical and nuclear. Hundreds of diverse specialties are included in a wide variety of work settings. For example, an electrical engineer may work in aircraft design, space systems, power production, communications or research. A mechanical engineer might be involved in aircraft structure design, space vehicle launch pad construction, or research.

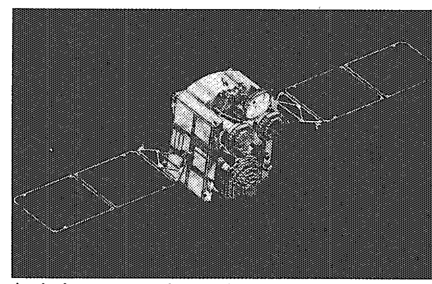
PROJECT RESPONSIBILITY COMES EARLY IN THE AIR FORCE



Air Force mechanical engineer inspecting aircraft jet engine turbine.

Most Air Force engineers have complete project responsibility early in their careers. For example, a first lieutenant directed work on a new airborne electronic system to pinpoint radiating targets. Another engineer tested the jet engines for advanced tanker and cargo aircraft.

OPPORTUNITIES IN THE NEW USAF SPACE COMMAND

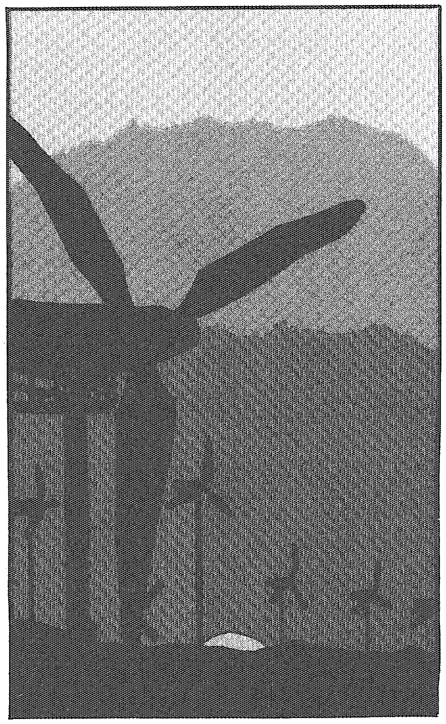


Artist's concept of the DSCS III Defense Satellite Communications System satellite. (USAF photo.)

Recently, the Air Force formed a new Space Command. Its role is to pull together space operations and research and development efforts, focusing on the unique technological needs of space systems. This can be your opportunity to join the team that develops superior space systems as the Air Force moves into the twenty-first century.

To learn more about how you can be part of the team, see your Air Force recruiter or call our Engineer Hotline toll free 1-800-531-5826 (in Texas call 1-800-292-5366). There's no obligation.

AIM HIGH AIR FORCE



As the sun dips below the horizon, wind mills at the Altamont Pass wind farm in California continue to generate electricity. Solar power and wind power are two energy sources which may be used more in the future. The cover was designed by Kay Kirscht.

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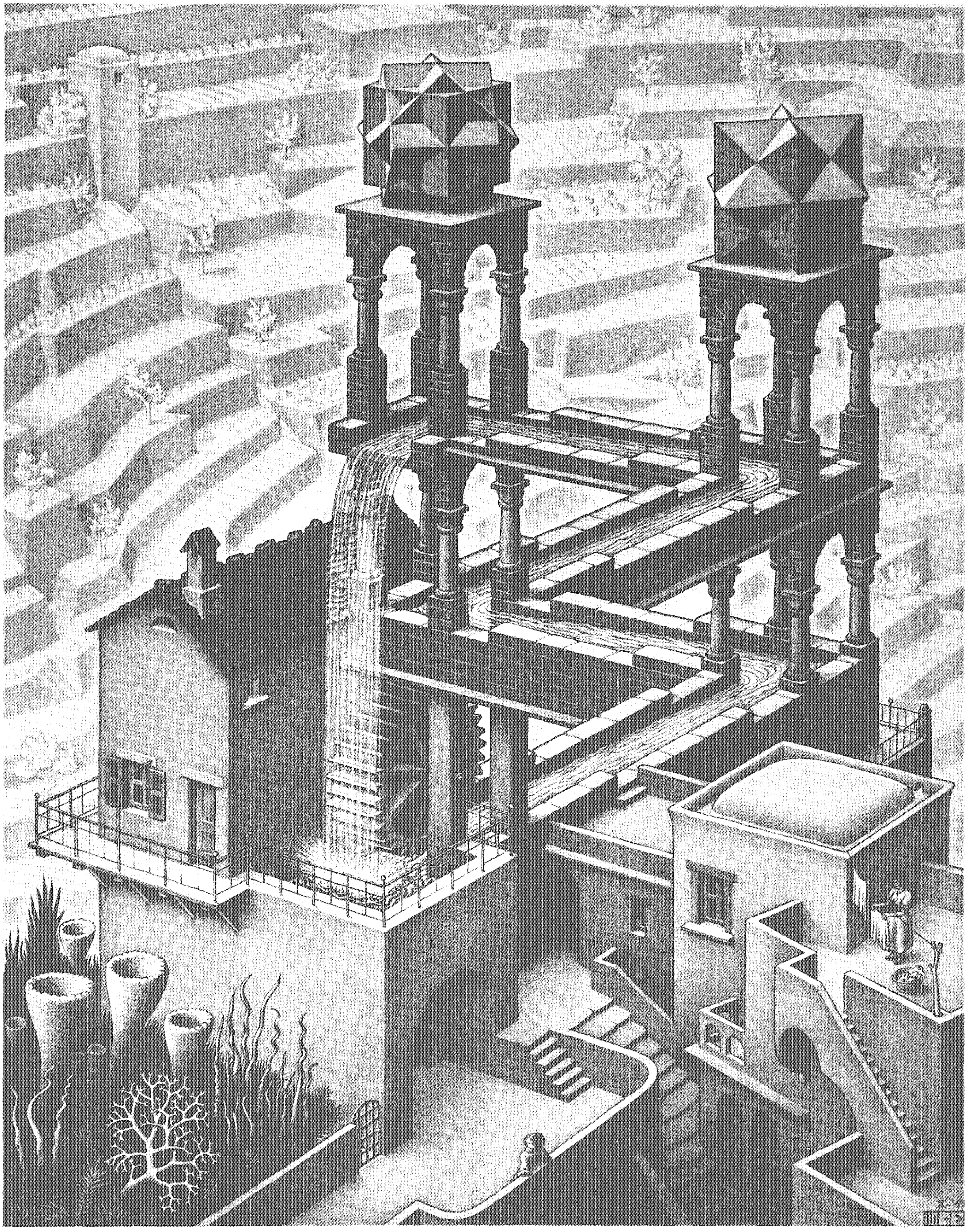
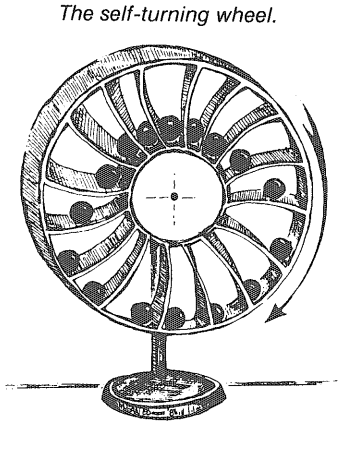


Editor's Log

Perpetual motion. Mankind has flirted with the concept of a perpetual motion machine for centuries. The self-turning wheel, a hollow wheel containing metal balls which move from the center to the outer radius and back again as the wheel spins, is a good example. Its basic design was described in a Sanskrit manuscript written 1,500 years ago and was refined by Leonardo da Vinci in the 15th century. It once again surfaced 200 years later in England. While in the Tower of London, the Marquis of Worcester so impressed the King of England with his description of such a wheel that he was released. Even today, over a century after thermodynamicists have shown the impossibility of such contraptions, the U.S. Patent Office still occasionally receives plans for a perpetual motion machine.

Why? Man holds an eternal belief that it is possible to "beat the system," to get something out without putting anything in. The age of extremely inexpensive oil did nothing to alter this belief. Easy to obtain, easy to transport, and relatively pollution free, oil allowed us to spend very little of our time and money on energy concerns and to achieve an unprecedented standard of living.

The self-turning wheel.



Herman Kahn, the noted futurist, once said that 20 years of prosperity were bad for any country, implying that abundance and waste go hand-in-hand. Such is the case with the United States, where conservation practices lag behind those of even the relatively prosperous countries of Western Europe.

The oil age, however, may prove to be one of the shortest ages in history. Only 124 years ago E. L. Drake drilled the first oil well, but it is estimated that world petroleum production will peak in the 1990s. Unlike previous energy era transitions, we are not leaving the oil age behind because we are able to make use of another energy supply which is less expensive or cleaner. Rather we are getting pushed out of the oil age into an unknown era. Granted, most people feel that mankind's ingenuity will eventually allow us to tap new energy supplies through the use of new processes such as fusion, but it is unlikely that anything will be found before the turn of the century.

The Challenge of Energy

With demand expected to exceed supply in the next decade, a certain amount of changing and adapting appears to be inevitable. We may have to alter our habits of wastefulness and affluent living, both of which are easily obtained but hard to break. Yet every barrel of oil saved now will ease the transition to long-term resources. Ideally, then, we should have a national energy policy which encourages conservation and research. Unfortunately the funding for many research and development projects has been cut by the current administration, and a true energy policy is still a thing of the future. Meanwhile, larger cars are making a mild comeback. The recent world oil glut has convinced people that there is nothing to worry about. Little preparation is being made for the coming change.

The reason for this can be found by noting that politicians tremor when the words "lower standard of living" are mentioned. But much of the problem is simply human nature. Just as you and I do not start working on a paper until the night before it is due, people in general will not really begin to worry about the problem of diminishing oil reserves until we are within the crisis.

The consequences of such a "last minute" policy and the importance of a conservation and research and development program are brought more clearly into focus by President Reagan's pledge to use force if necessary to keep oil flowing to the western hemisphere. Proper action now can lead to a future free of such a decision. Continuation down the present path, however, will not earn the approval nor respect of future generations. It is unfortunate that our children may view our large gas-guzzling cars and our energy wastefulness in much the same way as we view our fathers' perpetual motion machines: "They should have known better."

Al Hauser
Editor

Log Ledger

By Scott Dacko

- **Most Efficient Solar Cooler**

Scientists at the Department of Energy's (DOE) Solar Energy Research Institute (SERI) have identified a high-efficiency dehumidifier design which is expected to raise the coefficient of performance of solar desiccant cooling systems from 0.5 to 1.1—twice the efficiency of present solar air conditioners. The solar desiccant cooling system combines dehumidification, in the form of a silica gel dehumidifier, with evaporative cooling.

The silica gel in the dehumidifier extracts virtually all moisture from air passing around it, drying the air for passage through an evaporative cooler to produce comfortable cooling for the home. Solar heat then "regenerates" or dries the dehumidifier, thus renewing its ability to remove moisture from the air.

- **District Heating in St. Paul**

Hot water district heating has begun in St. Paul as a result of the completion of construction of the city's $45.8 million district heating project. The start-up of hot water services to downtown St. Paul customers comes seven months after the start of construction and over four years since system studies were initiated.

The initial system, not yet including the planned expansion, will pipe hot water heated at the District Heating Development Company's 3rd Street plant to downtown buildings to fulfill their space heating, domestic hot water, and processing needs. The private, nonprofit DHDC cites energy efficiency, long-term stable energy prices, environmental improvements, and fuel flexibility for the future as the system's benefits. By 1985 the system is expected to save enough gas and oil to heat 10,000 homes annually.

- **Welding Robots Can See**

A new sensor system developed by General Electric gives welding robots some of the powers of sight and intelligence. With the new system welding robots are able to steer themselves along irregularly shaped joints, continually observing the joint and weld puddles and are able to make adjustments as they travel along.

I.T.'s Bulletin Board

A series of lenses focus an image of the weld puddle and joint onto the end of a fiber-optic bundle. This bundle then transmits the image to a solid state TV camera, which, in turn, is linked to a microprocessor-based intelligent vision system capable of scene analysis, and thus, can issue corrective commands to control the many process parameters.

Joint tracking is accomplished by beaming two parallel laser stripes across the weld joint, which can be seen and analyzed by the vision system and thus issue directional commands.

- **Civil/Mineral Building Dedicated**

Ceremonies were held October 12 to dedicate I.T.'s underground Civil and Mineral Engineering Building. Several hundred attended to not only celebrate the building's dedication, but also to celebrate the fact that the building received the prestigious Outstanding Civil Engineering Award for 1983. If you have not yet visited the new building, please do!

- **New Acoustic Microscope**

A new acoustic microscope developed by GE, operating at a frequency 5000 times higher than the audible limit of the human ear, is able to detect and produce magnified visual images of tiny flaws in high-strength super alloys. The flaws may be as little as 0.01 inches wide and burried as deep as four inches.

A part to be examined is immersed in a tank of water, since the necessary sound wave frequencies of 100,000,000 cycles per second do not propagate through air. A transducer sends acoustical pulses along a rod which concentrates the pulses into a local zone which is then transmitted by the water into the part. The sound pulses bounce back from the part's internal structure and are then translated into electrical signals of proportionate amplitude. The signals are then used to produce dots of appropriate darkness on an electro-static printout. ■

Minnesota Peatland Potential and Policy

By Jim Lundy, Mary Wilkosz

Stagnant, I thought. Stagnant and dead. That is what this place is, where I stand, knee-deep in blackened water, decayed and decaying roots and shrubs wrapping my anatomy. A deerfly munched on my back, through my shirt. The only other living creature in these parts? Apparently not, for his subtle signal to his hungry friends brought a rush of buzzing that stirred me to sudden flight. What god-forsaken land this is!

"This land" was a peatland of the North Country of Minnesota, where a certain writer recently made a headlong foray into the sodden unknown. While goose-stepping across the mire, he frequently reminded himself of the respect this land demands, of the wealth that it holds, and that much recent scientific and political interest has been generated by country such as this. All the figures say, and from his own soggy vantage point they were easy to corroborate, that aside from Alaska, Minnesota bears the largest acreage (5.9 million acres) of peatland within the United States. These numbers hold what some guardedly hope is a fantastic promise of energy resources for the energy-dependent state in which we live.

Development of the peatlands of Minnesota is attractive not only for the as yet unknown number of megawatts of energy to be attained, but also for the gains to be had in connected industries such as horticulture and agriculture and for the economic boost certain areas of the state would undoubtedly enjoy. Though there is much to gain, there is also much at stake, as serious problems could result from rapid and unplanned development of Minnesota's peatlands.

Variously known as "muskeg," "mires," "moores," "swamps," "organic soils," even "young coal," peatlands are simply areas of poor drainage where dead organic matter accumulates faster than it decomposes. The original plant matter varies widely from aquatic organisms to reed-sedges, sphagnum, woody plants, and so on. As they die these organisms are submerged in water and buried beneath other dying material, undergoing a compaction of about 10-30 percent. Simultaneously, slow decomposition begins, involving a combination of inorganic oxidation and microbial and fungal breakdown of plant tissues into water, gases, minerals, organic compounds, and heat energy.

Several factors hinder the decay of dead material. The wet, stagnant, poorly drained environment of most peatland bogs inhibits the exchange of gases necessary for microbial activity. Short, cool summers and cold winters further delay evapotranspiration losses and slow metabolic rates of decomposers, causing additional delay to the decomposition process. It is thought that the geologic setting underlying the peatland has some significant but as yet unknown effect. These environmental conditions are favorable for the formation of coal deposits. However, most peatlands are only about 5,000 years old—not nearly enough time for the processes which produce coal to be effective.

Peatlands are found worldwide, but the largest concentration of peat is found in arctic or sub-arctic climates. In lower latitudes peatlands tend to occur over smaller areas near rivers, deltas, and rain forests.

Minnesota peatlands tend to be one of two types. An ombrotrophic bog, or raised bog, is a convex upward surface of vegetation which is dependent only on precipitation for its water supply. Raised bogs usually exhibit such vegetation as spruce, tamarac and sphagnum moss. Mineratrophic fens, on the other hand, are flatter and wetter than raised bogs, and receive their water supply from both precipitation and groundwater. Sedges, grasses, swamp birch, and willow are common in fens.

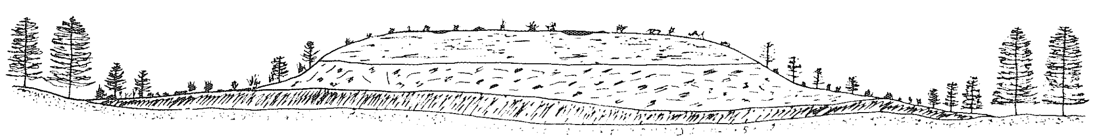
Raised bogs and fens are produced either by lakefill, in which the peatland advances inwards, thus slowly filling and eliminating the lake, or by paludification, in which the peatland advances outwards from the perimeter of the lake.

In cross-section, most peatlands have three identifiable horizons. The upper horizon, or fibric layer, is comprised of relatively undecomposed sphagnum mosses. The humic herbaceous horizon, underlying the fibric layer, consists of fibers of reeds, sedges, marsh grasses, cat tails, and so on. This is a partially decomposed, relatively less acidic layer. The sapric layer is almost entirely humified, dark brown to black unidentifiable material. The sapric layer suffers the most severe decomposition.

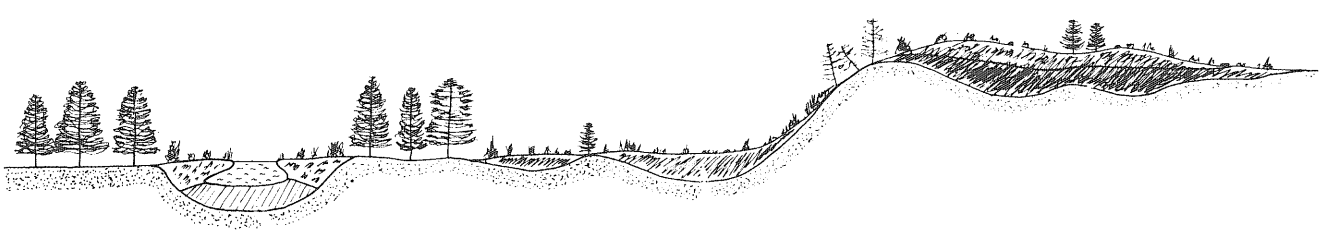
The most obvious reason for exploiting Minnesota's peatlands is as an energy investment. One researcher (Farnham, Rouse S., *Peat Resources...*, IGT, 1980, p. 12) has claimed that if one million acres of peat (one sixth of the area in Minnesota which is covered by peatland) were harvested to a depth of ten feet, the total energy output would be equivalent to a 32 year supply of energy for the entire state (38.4 quads of energy). This claim should be tempered with the fact that much of Minnesota's 5.9 million acres of peatland lacks energy development potential due to the depth, quality, size, environmental limitations, ownership, transportation networks, and public and private service systems. Hence a distinction must be made between peatland resources (the total peatland acreage) and peatland commercial reserves (the peatland acreage available for commercial use, a number governed by a set of known constraints).

While commercial reserves in Minnesota have not been estimated, the peatland gasification program of the Department of Energy has established some commercial development guidelines:

1) Peat must exist to a depth of at least five feet.
2) Peat may only be extracted from peatlands containing 80 acres of contiguous peat per square mile.
3) Peat must contain a minimum of 8,000 BTU's per pound.
4) Peat must contain less than 25 percent ash by weight.



Simplified diagram of an ombrotrophic bog.



Schematic diagram of a minerotrophic peatland.

Courtesy of Monenco Ontario Limited, 1981: Evaluation of the Potential of Peat in Ontario; Ontario Ministry of Natural Resources, Mineral Resources Branch, Occasional Paper No. 7, 193 p.

Even with these restrictions in mind, peatland reserves in Minnesota are sizeable, and one can easily see what all the fuss is about.

The use of peat for fuel began thousands of years ago, as there is evidence of sod peat being burned in Europe at the beginning of recorded history. Large scale peat harvesting did not occur until the early 1700s in Russia, and by the turn of the century 1.65 million tons of peat were being harvested there each year. Some countries (for example the USSR, Finland, and Ireland) use peat energy on a large scale, though in many other places (northwestern Scotland, parts of Germany, and elsewhere) peat is used for domestic heating, and has been thus used for generations. The use of peat energy is not a new idea. It only sounds new to Americans, who have until recently enjoyed cheap and abundant energy supplied by other sources.

Peat utilization was first discussed in Minnesota nearly one hundred years ago, when the state legislature appointed a committee to look at the feasibility of using peat as a fuel for locomotives. More recent interest in peatland development stems from worldwide energy problems. "I believe that the problems in the world are caused by the high cost of energy," Governor Rudy Perpich said in a recent interview with *Technolog*. To this end, he hopes to "develop resources indigenous" to Minnesota, including wind power, solar power and peat.

A myriad of non-energy related peat uses have been found. Peat can be used as a soil conditioner and as a potting soil; fortified with fertilizer, it can be spread like manure; it can be used as a filtration material; peat can be used to absorb oil spills; when processed, it can be used to produce carbon, coke, ethyl alcohol, and tars and waxes; it is useful as an insulating material. But the use of peat arousing by far the greatest interest concerns the production of peat energy.

How is peat converted from its very soggy initial state to a state suitable for burning as an energy source? The extraction of peat, or peat mining, is preceded by a series of steps beginning with a peat survey. The survey determines the characteristics, location, extent, and depth of the peat in the area being considered for development.

If the quantity and quality of the peat are high enough, development continues with the drainage of the peatland. These areas often contain up to 90 percent water, so in order to avoid losing heavy machinery in the mire, extensive drainage networks must be constructed. Once the peatland has been drained so that it can support the required machinery, trees, stumps and bushes must be removed. The peatland surface is then leveled to facilitate the actual mining process. The above procedures must be completed before mining can begin and may take up to several years to complete.

When the peatland has been fully prepared for mining, one of several mining processes can be chosen. Block cutting of peat is the most labor intensive as well as the oldest method for peat mining. Raw peat is cut by hand from a vertical face, sliced into blocks, and left to dry in the air and sun. Drying time varies considerably, but two months is usually sufficient to reduce the moisture content to about 30 percent. This method has been used almost exclusively to produce domestic fuel, though block cutting machinery has been used in Germany to produce commercial quantities.

Sod peat mining involves cutting peat from the sides or banks of trenches 3 to 4 meters deep. A macerator mixes the peat under pressure and breaks down the lumpy pieces and fibers. Uniform sods of greater density than the original peat result, and these are left on the ground to dry. The sods are turned again and again, accelerating the drying process, which takes from 5 to 20 days. When the moisture content is reduced to about 35 percent, the sods are collected and stored or transported. Multiple harvests of sod peat can be expected in a year's time, with each harvest yielding about 30 to 40 tons per hectare.

Milled peat mining has been in use in various forms for at least 120 years. This procedure involves cutting a thin layer (about a half inch) of peat from the surface, allowing it to dry, and collecting it by various methods. The ridged peat method lets the milled, fluffed peat dry in the field, encouraged by one or several harrowings. The vacuum peat method employs a large vacuum collector which deposits the milled and air-dried peat into large storage tanks.

"Wet mining" procedures, including hydraulic mining, involve removing peat from the site without solar drying. Water is added to the mined peat to create a slurry which is then transported to a holding tank, where artificial drying shipment is used to reduce the moisture content. Wet mining offers certain advantages over

Governor Perpich during an exclusive Technolog *interview.*

Photo/Ed Wollack

the other mining methods, including the following: its potential use in areas otherwise unsuitable for peat extraction (for example, where surface drainage is impossible), a greatly increased production season, and anticipated lower costs.

But problems remain. Each of these procedures may pose as yet unseen or poorly understood environmental problems. Two of the methods involve extensive drainage of a peatland, a third involves the production of a large amount of slurry which must ultimately be disposed one way or another. Cost estimates of each complete process for extraction are difficult to determine. Much equipment remains to be developed. Dewatering is a tremendous technical problem which, at this point, is either phenomenally cost- or energy-ineffective, or sadly dependent upon the whims of the weather.

After mining one of several methods may be used to produce energy from the peat. The most straightforward of these involves the direct combustion of the dried peat either in special furnaces (for domestic purposes) or in large electric generating plants. Although not used in the United States, this method has been widely used elsewhere, largely with success. The Soviet Union has 76 generating plants with a combined capacity of 4000 megawatts consuming 80 million tons of peat annually. Finland and Ireland are also successfully using this process.

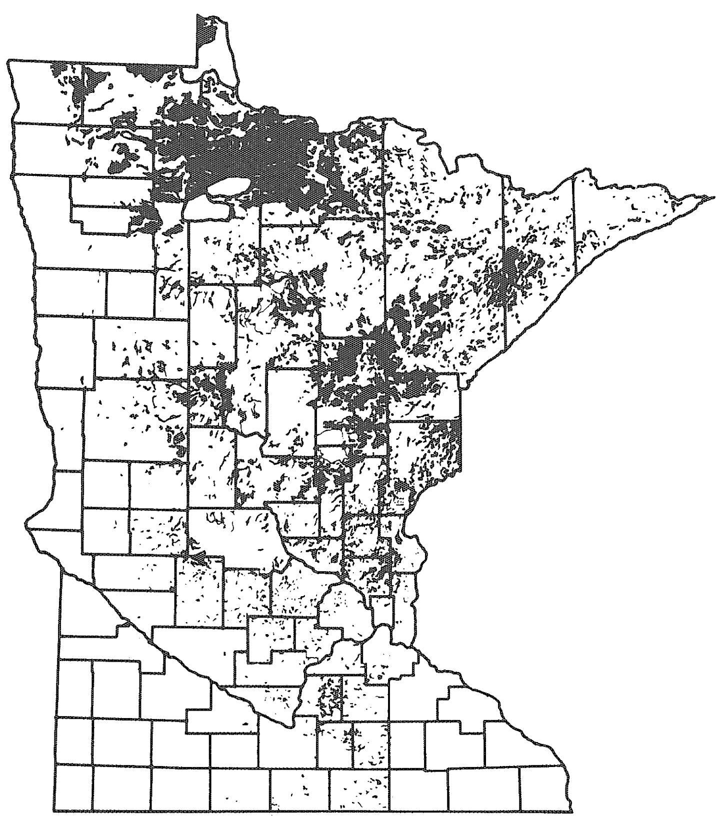
Gasification of peat is another process by which the energy in peat can be made useful. This process converts peat (or other solid carbonaceous fuels such as coal or biomass) to a gaseous fuel that can be burned directly, upgraded to a higher fuel such as synthetic natural gas (SNG), or used as feedstock, or in manufacturing chemicals such as ammonia or methanol. This is achieved through either biogasification or hydrogasification. Biogasification, a new and as yet unproven process, requires that anaerobic microorganisms in the peat act as catalysts for the fermentation processes, which changes organic material to methane and carbon dioxide. The methane is then purified and burned for energy, while the waste products can be used for animal feed or soil conditioners. Since biogasification does not require dewatered peat, it could result in a significant reduction of costs. Hydrogasification is also still in the developmental stages but relies on a process similar to that of coal gasification. Peat is combined with steam and air or oxygen under high pressure and temperature to produce SNG.

Liquefaction of peat is the third available energy technology. Direct liquefaction requires that wet peat is treated under high temperatures and pressures for a short time in a reducing atmosphere. A heavy oil, called bitumen, results, and can then be burned directly as a fuel. Indirect liquefaction requires first that the peat be gasified to produce SNG. Catalysts are then used to produce a liquid fuel. Liquified fuel is versatile, as it is useful not only in producing heat and electricity, but for running engines as well. Thus liquified peat may one day be important as a substitute for gasoline. However, peat liquefaction is not considered an integral part of Minnesota's energy plan due to the required initial expense of the liquefaction process.

Briquette production is the fourth nonrenewable peat energy option and the most energy-efficient. It produces a concentrated piece of peat in the shape of a small pellet or briquette. These briquettes are used for domestic heating or for burning in small industrial boilers. To make briquettes, dewatered peat is transported from the peatland to the briquette plant, where it is blended into a homogeneous product. The peat is then milled to produce particles approximately 10mm in size, after which it is heated to dry it. The resulting powder is then pressed into briquettes of any desired size, usually with a heating value of 7200 BTU/lb. The pellets can then be sold as a domestic fuel or for industrial use.

The production methods discussed so far rely upon the nonrenewable development of peatlands. Another strategy exists which may prove beneficial for Minnesotans to consider: that of renewable peatland development. More specifically, this

Continued on page 38



Minnesota's peatlands.

Satellite Power System: Harnessing the High Frontier

By Ken Jopp

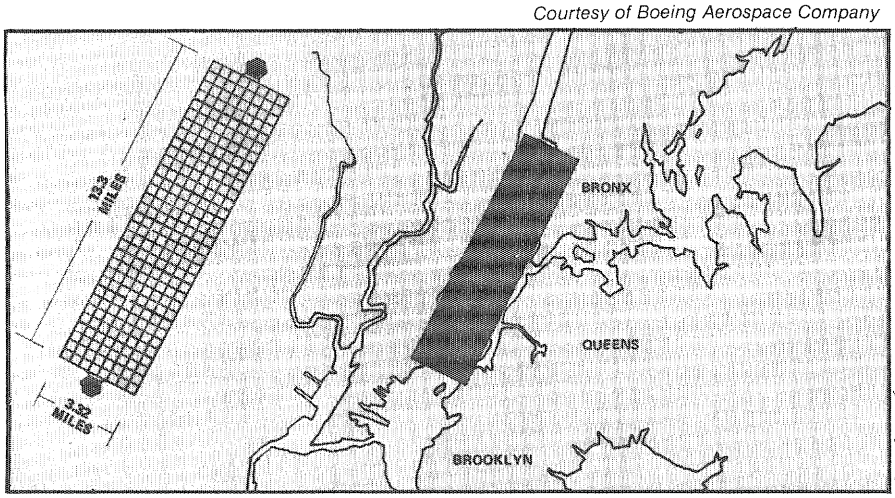
As global energy consumption depletes fossil fuel reserves, it becomes clear that alternative energy sources need to be developed. Even at the current moderate growth rate of two percent, the world's petroleum reserves should be 90% exhausted around the year 2030; natural gas may last a few decades beyond that. And while there still seems to be plenty of coal in the ground, the acid rain coal burning produces increasingly concerns environmentalists. For these reasons, if we are to guarantee a sufficient energy supply for the world's growing population, we are going to have to develop unconventional energy sources.

Future energy alternatives will have to provide the benefits while avoiding the pitfalls of the fossil fuels they replace. They will need to satisfy the rapidly growing global market, and at the same time, be compatible with the Earth's delicate ecological balance. One proposed future energy source which promises to meet global demands while generating "clean" energy is the Satellite Power System, or SPS.

The SPS concept involves building and placing in orbit large solar cell arrays which would collect solar energy continuously and beam it, via microwaves, to ground receiving antennas. The receiving antennas would then convert the incoming beams to electricity to be fed into existing power grids. SPS would use existing solar cell technology, with the advantage of freeing it from the limitations imposed by the terrestrial environment. Such limitations include day/night cycles, weather disturbances, physical obstructions, filtration of sunlight by the atmosphere, and the small scale on which solar cell users are forced to operate. Above the atmosphere there are no barriers to sunlight and construction can be carried out on a very large scale.

One photovoltaic (solar cell) solar power satellite superimposed on a map of New York's Manhattan Island. One such satellite would be able to beam to Earth 10,000 megawatts of electricity.

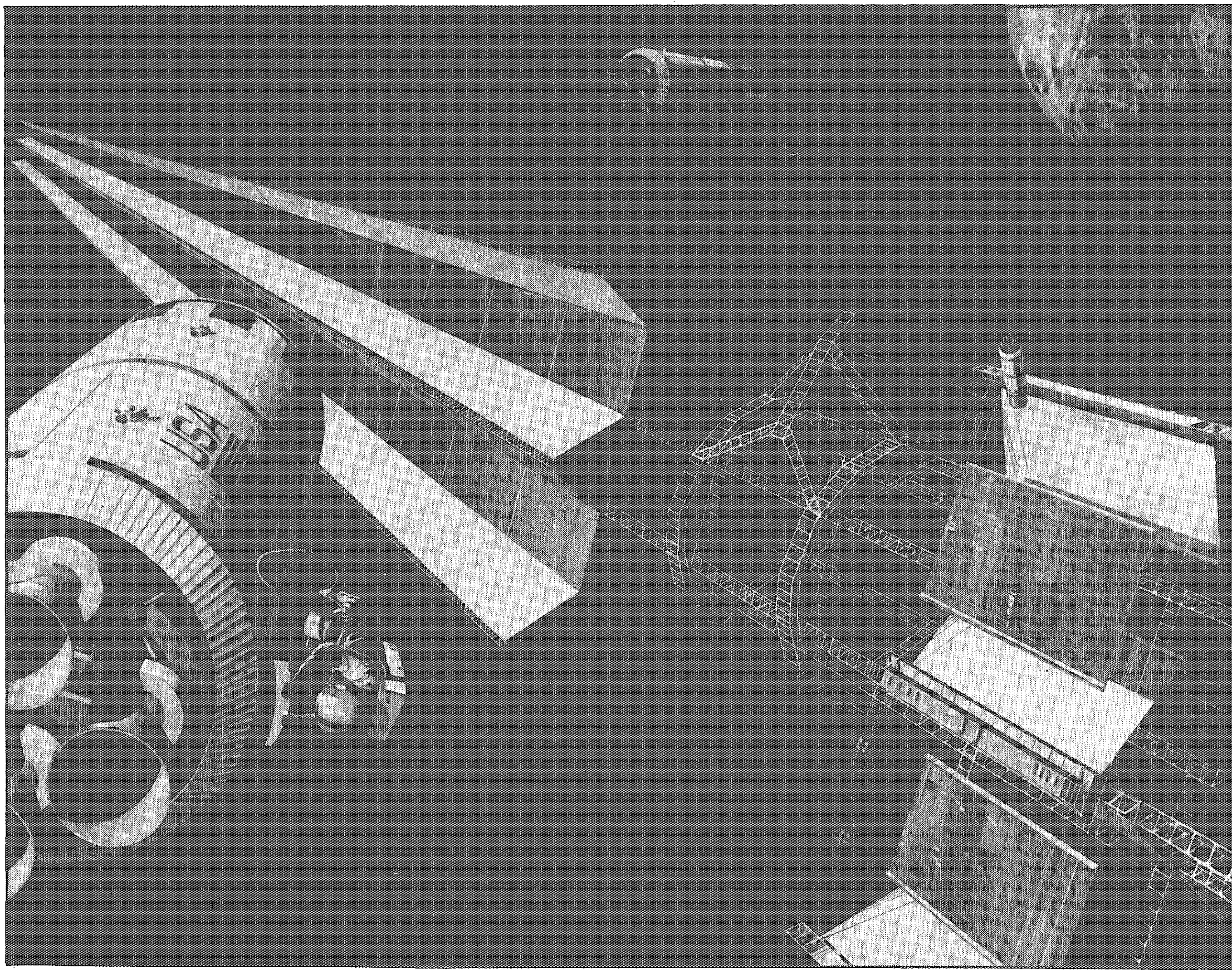
Courtesy of Boeing Aerospace Company



NASA has been using solar cells in space for over twenty years to power satellites, planetary probes, and manned spacecraft. It also has demonstrated the technical feasibility of remote power transmission by means of microwaves.

These two ideas were brought together in 1968 by Dr. Peter Glaser of Arthur D. Little, Inc. In an article in *Science* magazine Dr. Glaser first proposed using solar cells in space to collect solar energy for transmission back to Earth. In 1976 the federal government took this idea seriously enough to commission a thorough evaluation. In 1977 The Department of Energy (DOE) and NASA began a "Concept Development and Evaluation Program" to determine the technical, economic, and environmental feasibility of SPS.

The DOE/NASA study was based on a reference system, or theoretical model of SPS. The reference system called for sixty satellites, each made of a flat solar cell array of about fifty square kilometers with a microwave transmitter (1 km in diameter) mounted on one end. For each satellite assembled in Earth orbit, an elliptical receiving antenna (10 x 13 km) would be built on Earth. The satellites would be in a geosynchronous orbit, travelling at the same speed as Earth rotates so as to remain fixed over their respective



Courtesy of Rockwell International Corp.

Construction of a solar collecting satellite taking place in geosynchronous orbit.

receiving antennas. Visible from Earth, the satellites would appear as a string of new stars in the night sky.

The DOE/NASA also looked at some alternatives to this model. One involved using lasers to transmit the collected energy to Earth. Lasers, however, were found to have some serious drawbacks. For example, temperature gradients in the atmosphere would unpredictably bend and distort the beams. Also, while the laser beams would probably not pose a threat to aircraft because of their high reflectivity and speed, insects and birds passing through the beams would be incinerated. Animals might even be attracted to the beams. SPS-type microwaves, on the other hand, would not pose these hazards.

Built according to the reference system design, SPS could not be used as a weapon, and accidental exposure to populations would be impossible, since the incoming beams would be steered by a small "pilot" beam sent up to the satellite from the receiving site. A wandering beam would be automatically defocused, dissipating its power harmlessly into space.

However, even with a properly operating system, there would be some spillage of microwaves outside the receiving sites. Preliminary calculations show that such spillage would be within accepted limits, but further studies need to be done to determine the biological and ecological effects of long-term exposure to the low density microwaves SPS would generate. The reference system calls for receiving sites to be located far from populated areas. High fencing and exclusion areas surrounding the sites would also be implemented as safeguards.

Another environmental concern involves geological displacement from the system's required mining operations. Each satellite, based on the reference design, would require some 14,000 tons of silicon, 151,000 tons of aluminum, and 15,000,000 tons of steel, along with other materials. Building a complete 60 unit SPS would involve the largest mining operation ever.

Some advocates have instead proposed using lunar resources for SPS satellite construction. A typical sample of lunar soil contains, by weight, about 20% silicon, 12% aluminum, and 4% iron, the materials most needed for SPS satellite construction. Using lunar materials would eliminate the high cost of launching heavy payloads from Earth and would bypass potentially disruptive mining operations. Princeton University physicist Gerald K. O'Neill has already demonstrated a working model of a catapult-like device which could be used to launch payloads of lunar material into space for processing.

Other environmental concerns involve the large land area the receiving antennas would occupy. However, if all the electricity for the U.S. in the year 2000 were provided by SPS, the necessary receiving sites would cover only 0.2% of the total land area of the continental U.S. Ground based solar cells would require four times as much land area to provide the energy. It has even been suggested, since the receiving antennas would absorb only microwaves and let sunlight and rain pass through, that normal activities such as livestock grazing could still be carried out beneath the receiving antennas. Offshore sites have also been suggested.

Unlike fossil or nuclear fuels, which deposit as waste heat into the biosphere nearly one and one half times as much energy as they put into the power grid, SPS would release only a small fraction of its total power as waste heat.

In these and other regards the system appears to be environmentally sound. The Office of Technology Assessment of the U.S. Congress and the National Academy of Sciences conducted their own studies of SPS. Neither these, nor the DOE/NASA study, identified any prohibitive ecological hazards for the system.

As for the usefulness of SPS as an energy supplement, NASA calculated that each satellite would provide 500,000 kilowatts of power. The U.S.'s total electrical capacity in 1975 was 228 million kilowatts. Assuming an annual growth rate of 3 percent, the U.S.'s capacity for electric power would grow to 483 million kilowatts by the year 2000. Sixty 500,000 kilowatt satellites would provide 300 million kilowatts of electric power, a significant portion of this amount. amount.

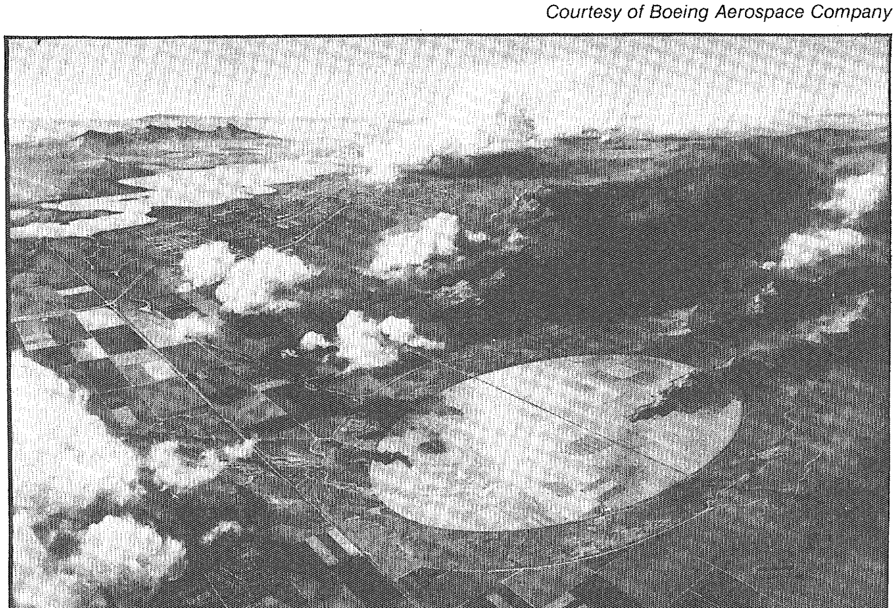
The DOE/NASA reference system is only one model, however. In his book *The Space Enterprise,* science writer G. Harry Stine points out that more powerful satellites would be more economical. He calculates that a million kilowatt satellite could be built for about as much as an equivalent coal-fired power plant (about $1500-$2000 per kilowatt). He also points out that costs could drop by as much as 50% for satellites made of extraterrestrial materials. The major economic obstacle at this point is the enormous initial investment the system would require.

While SPS appears promising, the government has been less than enthusiastic about endorsing it. The National Academy of Sciences recommended that NASA be given responsibility for monitoring research that could affect the development of SPS, but that no funding be provided for research specific to it. The Office of Technology Assessment also recommended that NASA monitor relevant research and that funds be provided at either a 5-10 million dollar level or a 20-30 million dollar level for research on the tehnological and environmental issues associated with SPS.

It's not surprising that such an exotic proposal would be met with caution. But as our conventional energy sources dry up, we will of necessity have to consider unconventional alternatives. SPS would be a reliable source of abundant, pollution-free energy and a valuable supplement to the many other energy sources yet to be developed. ■

A solar power satellite's energy would be beamed to Earth in the form of microwaves. These radio waves would be received by an antenna measuring some 5 miles by 7½ miles which would transform the waves to electricity for use in homes and factories.

Courtesy of Boeing Aerospace Company



Ken Jopp is a technical communications and psychology senior. When he heard about the vast acreage of wasteland required for a SPS microwave receiver, he immediately volunteered his dorm room.

Coal Gas: New Life for an Old Fuel

By Randy Smith-Kent, Al Hauser

As energy costs continue to rise, many industrial companies are waiting for new energy sources to appear on the horizon. Some researchers, however, are looking over their shoulders and finding a very economical and environmentally safe energy technology which has been used extensively in the past. Black, Sivalls and Bryson (BS & B), a subsidiary of the Gulf Resources and Chemical Corporation, and the University of Minnesota's Particle Technology Lab are operating a research coal gasifier and are obtaining some very encouraging results. The gasifier, located at the Twin Cities Research Center of the U.S. Bureau of Mines, is the only facility in the country where a variety of low-grade coals are being transformed into cost-competitive, low-Btu gas—all the more remarkable when one considers that this particular gasifier was built in the 1950s.

Far from a new technology, coal gasification can be traced back to 1792, when a Scottish engineer by the name of Murdoch lighted his home with gas obtained from the distillation of coal. In 1812 coal gas was used for street lighting in London. Soon after the other major cities of Europe followed this lead. By the end of the nineteenth century, coal gas was routinely used for many domestic and industrial applications. The presence of gas fixtures in many turn-of-the-century homes testifies to the role it played in home lighting.

Just how numerous were coal gasifiers? "The number that is quoted is something like 11,000 to 12,000 gasifiers in their heyday, probably the mid-thirties," said Rolf Maurer, manager of BS & B's coal gasification division. Approximately half of these were used by the steel industry. Other uses included glass melting, food processing, and the manufacturing of pottery. Across the Atlantic, Germany used coal gas to run its industrial war machine during World War II.

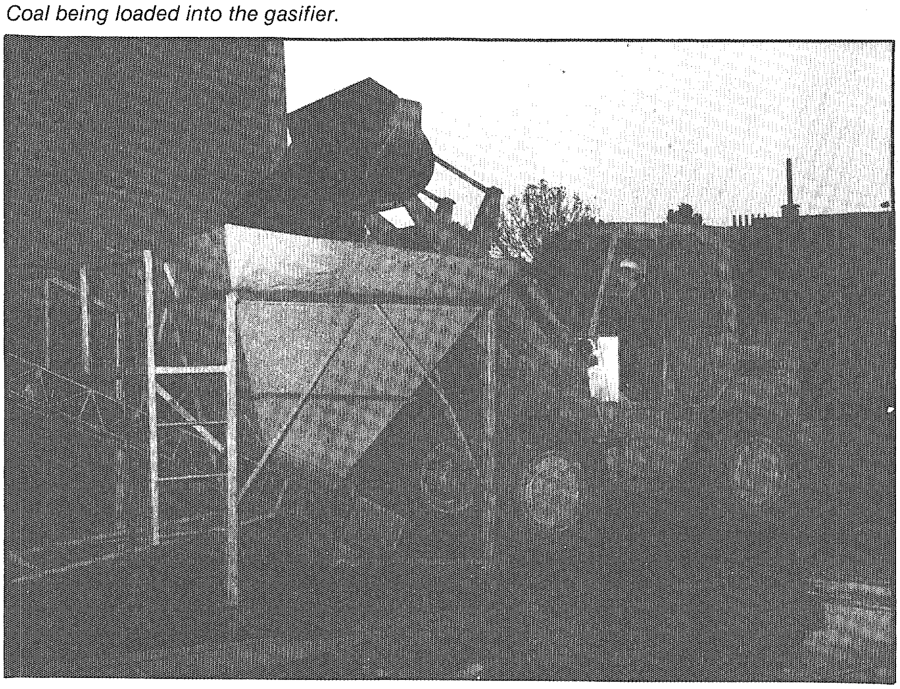
After the war, however, the availability of natural gas led to the gradual displacement of coal gas. The discovery of large reserves of easily obtainable natural gas in Texas resulted in falling prices. This, coupled with rising coal prices, caused the near extinction of the coal gasifier. Today there are only a handful of coal gasifiers operating in the United States.

Now, with the spiraling cost of natural gas, dependence on foreign oil supplies, and the relatively inexpensive price of coal, many companies are again taking a serious look at coal gasification. In April 1980 the Mining and Industrial Fuel Gas Group (MIFGA) was formed. Composed of a number of private companies (including BS & B) along with the Department of Energy, the U.S. Bureau of Mines, and the Environmental Protection Agency, MIFGA soon began testing the feasibility of replacing natural gas with low-Btu coal gas in an industrial setting at the Twin Cities gasifier.

Even though the technology is very old, there is still much to be learned about coal gasification.

"You're plowing new ground with old technology," said Maurer. "The application of industrial gasifiers [in

Coal being loaded into the gasifier.



the past] was restricted to specific types of coal, principally anthracite coal. One of the major thrusts of this program is to determine how western coals gasify in a single-stage, fixed-bed gasifier. People don't have too many questions about how anthracite gasifies, but there isn't any anthracite in the western part of the country, and anthracite is not a viable coal for Minneapolis or the iron range."

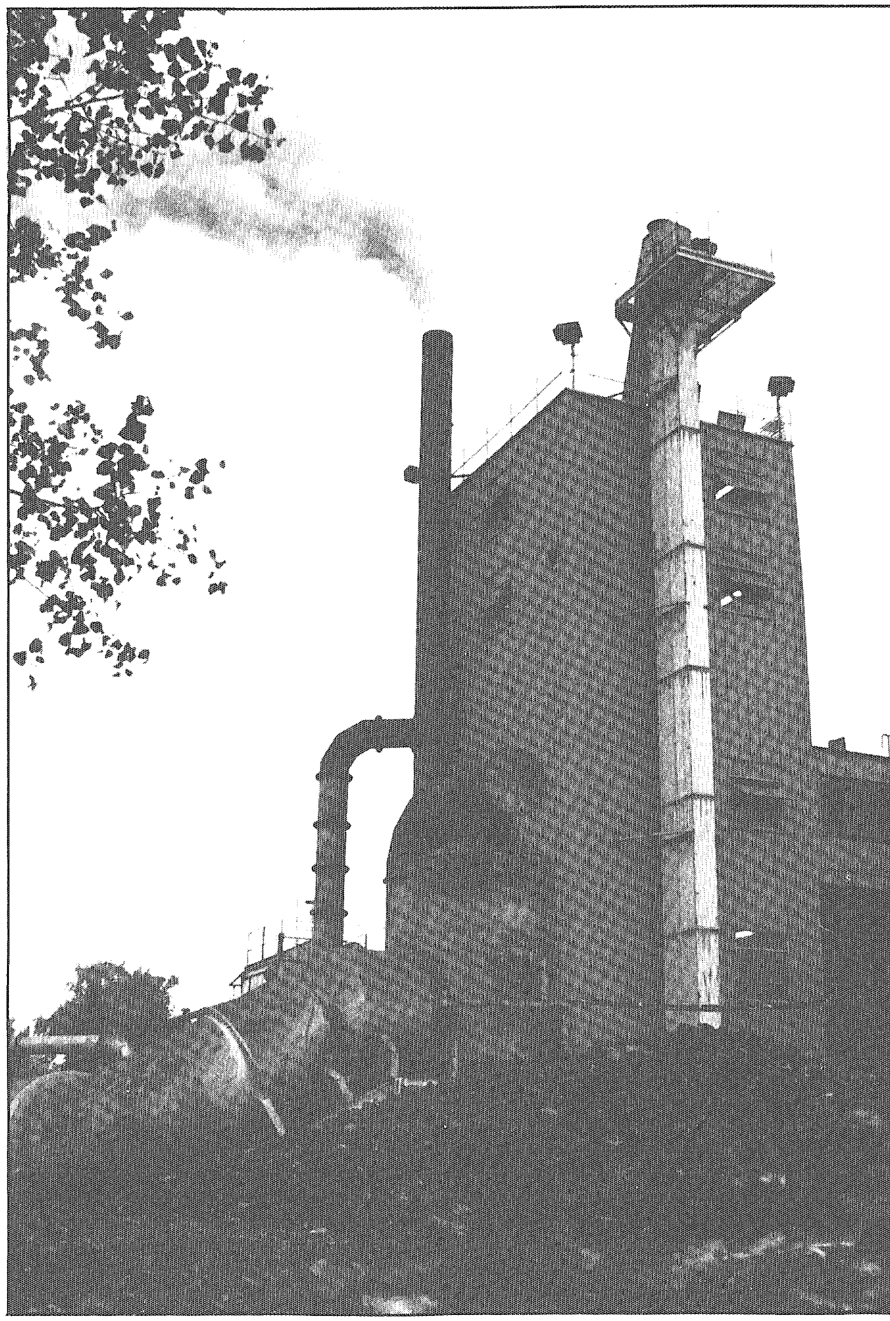
"These units were also operating under totally different environmental constraints: sulfur emissions—there wasn't a thought regarding SO_2 emissions in the '30s; tar and oil handling—the willingness of labor to get in there with sledge hammers to clean out lines, their management's willingness to let tar- and oil-gummed lines be burned out, billowing black smoke."

The project will hopefully yield important insights on the physics and chemistry of the coal gasification process. Questions relating to material and energy balance, coal devolatilization and the particle generation process will also hopefully be answered.

Two years ago BS & B applied for a contract to operate the Twin Cities gasifier for MIFGA. Shortly thereafter Dr. Benjamin Liu, a mechanical engineering professor and director of the Particle Technology Lab at the University of Minnesota, became involved.

"They came to the University wondering whether we would be willing and happy to work with them on the project. So we discussed [the possibility of University involvement], and we were very impressed by what the project could provide for the University in terms of the new research opportunities. We went along and put in a proposal with Rolf Maurer and BS & B to the Bureau of Mines, and we were the team that was picked for the project"

Liu assembled a group of faculty, graduate students and undergraduate students, primarily from the Mechanical Engineering Department's Particle Technology Laboratory, and began to acquire the equipment necessary to perform the University's portion of the project. The group was led by Dr. David Pui, also of the Particle Technology Lab. Said Liu, "The University has a responsibility in terms of the data acquisition, analysis, and what I believe to be the scientific aspect of the project." Calculating and measuring plant efficiencies, gas compositions, and the percentage of tar and water in the coal gas are some of the end results of the team's labors.

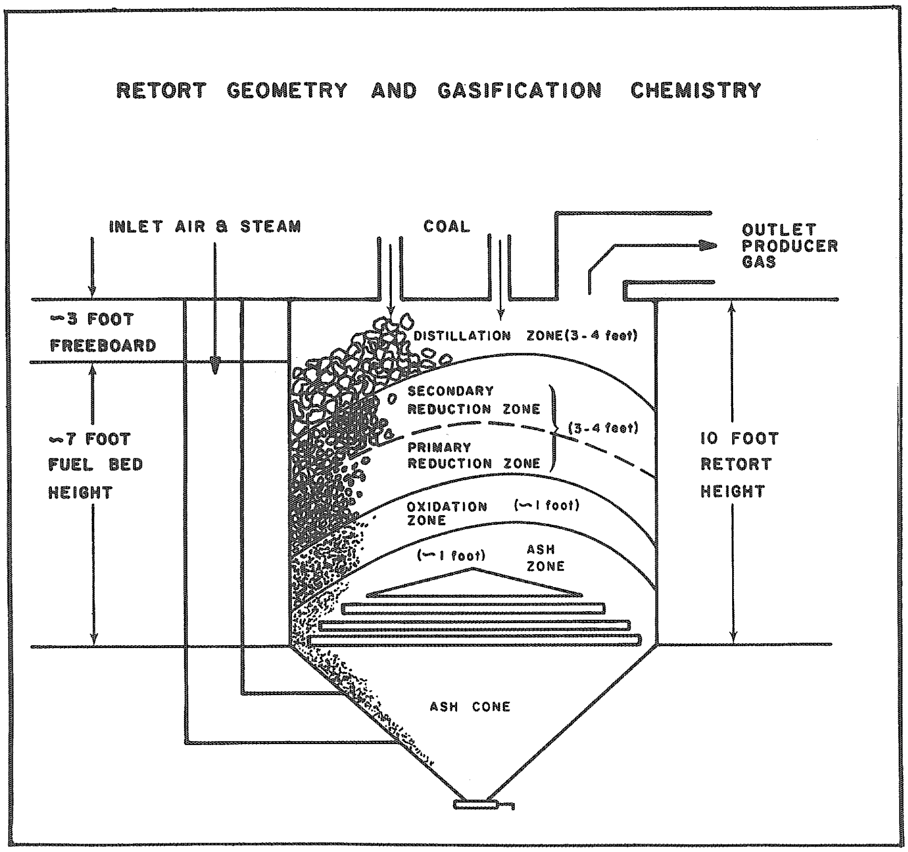


Photo/Ed Wollack

The Twin Cities gasifier.

There are several different types of gasifiers, but the one operated by BS & B and the University is a Wellman-Galusha fixed-bed gasifier. In gasifiers of this type the coal bed remains relatively stationary. Built in the 1950s, it still works as efficiently as when it was new. The gasifier's durability is a result of its simplicity, an advantage this system has over more complicated gasification schemes.

Coal is dumped into a holding bin from which it is periodically fed into the large (6.5 foot inner diameter), cylindrical retort. Surrounding the retort is a water jacket, where water absorbs some of the heat given off by the combustion of the coal. Air is forced over this water jacket and



becomes saturated or nearly saturated. Steam is added directly to the air stream if enough moisture is not present after the air has passed over the water jacket. The air next enters the bottom of the retort and flows upwards, through the coal. It first passes through an ash zone, which forms on the bottom of the retort. Continuing upward the saturated air encounters the oxidation zone. Here carbon from the coal combines with the oxygen in the air to yield carbon dioxide. Heat is given off since the reaction is exothermic. A mixture of water vapor, carbon dioxide, and nitrogen leaves the oxidation zone and enters the reduction zone. Carbon from the coal reacts with the carbon dioxide and the water vapor to produce hydrogen, carbon monoxide, and more carbon dioxide. Some of this carbon monoxide also reacts with the water vapor to yield more hydrogen and carbon dioxide. The resulting mixture enters the distillation zone and, due to its high temperature, causes the coal in this zone to be devolatized. The volatile matter enters the gas in the form of methane and other hydrocarbons, as well as oil vapors.

The gas itself is composed of approximately 28 percent carbon monoxide, 15 percent hydrogen, two to three percent methane, three to five percent carbon dioxide, and 50 percent nitrogen. (All percents are molar percents.) Actual amounts vary with different types of coal. As this raw gas, or producer gas, leaves the retort, coal dust is swept along with it. The effluents of the distillation and reduction zones leave the retort together; thus this gasifier is called a "single-stage" gasifier, as opposed to a "two-stage" gasifier, in which the tar-rich gas leaves the retort separate from the majority of the effluent formed in the oxidation zone.

Throughout this process carbon is being removed from the coal so that by the time the coal reaches the bottom of the retort only a gray ash remains. A rotating grate continuously forces this ash into a holding bin which is periodically dumped. The ash, which is classified as nonhazardous waste, can be used as fill, as bedding for railroad tracks, or in the manufacture of cinder blocks.

Thus, in a single-stage gasifier such as the one being operated by BS & B and the University, air, water, and coal enter the retort and producer gas, laden with dust, steam, and tar and oil vapor leaves the retort. A cyclone is used to remove the dust particles from the producer gas.
If the gas user is able to utilize the tar-laden producer gas and if the gasifier is located on the same site as the gas-using facility, no further processing is necessary. Aluminum melters and lime kilns are potential users of such a system. The thermal efficiency, defined as the energy in the desired product divided by the energy into the process, would be 85 to 90 percent (assuming a bituminous coal) for a gasifier operating in such a system.

If the user requires tar-free gas, a tar-removing device, such as an electrostatic precipitator (ESP), is necessary. Systems using pipelines of several hundred feet or longer require tar-free gas since any tar in a contained gas flow will condense onto the walls of the pipe as the gas cools. Multiple burner systems also require tar-free gas to avoid condensation in the small nozzles. A brick kiln is an example of one such system. Glass and pottery manufacturers would require cold, tar-free, desulfurized gas to avoid discoloration of the final product. The tar is recoverable and has a viscosity and heating value roughly equal to number six heating oil, making it very marketable. Still the sensible heat of the gas is lost, and the thermal efficiency of a process utilizing only the tar-free gas is 70 to 75 percent. Again, a bituminous coal has been assumed, and values vary with different types of coal.

The University team operates a sampling system which is located downstream from the cyclone. Producer gas passes through a condenser and an ESP, both of which remove tar and water. Next a refrigerator cools the gas, condensing and collecting any remaining water vapor. As a final check, the gas is forced through a chemical desiccant before it passes through a flow meter. Since both gas flow and tar and water weights are recorded, the amount of tar and water present in a given volume of producer gas is easily determined.

The dry, clean gas is pumped up to the University's instrument room, where it is analyzed by a series of gas chromatographs, infrared analyzers, and a calorimeter. From these instruments the heating value and the composition of the gas are obtained.

Particle sampling and ash analysis are also performed by the University team. A microcomputer records various temperatures, pressures and flowrates throughout the gasification process. Together these sources can yield in-depth information on the performance of the gasifier over any given time period.

In the past years several patterns have emerged from testing at the pilot gasifier. It has been found that gas quality increases with decreasing coal rank. Low-grade coals, such as North Dakota lignite, tend to yield very high quality gas. Western subbituminous coals also gasify well. The fraction of coal converted to tars and oils was found to be considerably higher than expected. And the gasifier start-up time was generally quite short—about 1½ hours.

It has also become apparent that university-private business ventures can be highly beneficial for both parties. BS & B has benefited from the expertise and extensive facilities of the University. And, although at first there were reservations, the University students have shown themselves to be dependable and resourceful workers. When asked about this, Liu said that he felt the students had proven themselves.

"If they [MIFGA] had any reservations at all about the University being able to perform, I think that fear has been largely allayed by the excellent performance that we've been able to deliver.... In their previous experience with this gasification plant, they have never run so well in terms of the data acquisition system running flawlessly for long periods, the gas sampling system running for long periods and also the gas chromatograph."

The chance to participate in a research project with private business has also been a unique and worthwhile experience for the students.

"Basically I think this project provides opportunities for students to experience not only research work but to do some kind of engineering work, which is very valuable experience," said Dr. Liu. "It is typical of the industrial experiences the students may find when they go to work in industry.... Thus far we have been able to provide employment opportunities for students—allow them to earn some money—and at the same time have them produce some very useful work for us."

The encouraging results of the Twin Cities tests have caused much excitement due to the many advantages coal gasification has compared to conventional methods of burning coal or natural gas. Many industrial applications require a gaseous fuel supply and must now use imported natural gas. Coal gasification would allow these industries to utilize domestic coal. The good results obtained from the gasification of western coals in particular seem to indicate that these vast reserves could be utilized by gas-fueled western industries. The replacement of natural gas by a domestic energy source will reduce the United States' dependence on foreign energy supplies.

There may be environmental advantages to using coal gasification in power generation.

"The role that gasification plays in power generation is that it offers an opportunity to clean up the sulfur or anything else you want to clean using a much smaller volume of gas before it enters the combustion chamber," stated Perry Blackshear, a mechanical engineering professor not associated with the project.

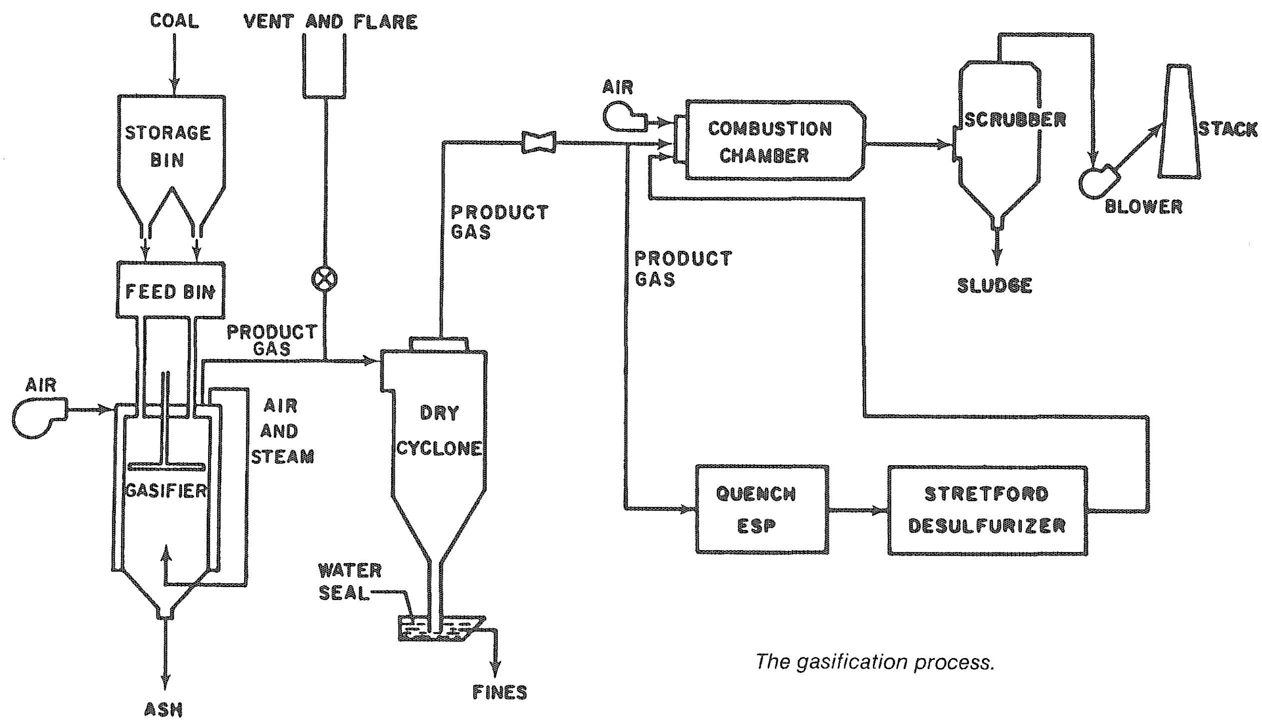
Gasifiers also have a relatively long life. "The equipment can run in excess of 20, even 30 years," said Dick Pooler, manager of BS & B's Twin Cities operations. Few moving parts and the slow speed at which these parts do move contribute to the long lifetime and alleviate the necessity of employing many highly skilled workers.

Pooler also commented on the impressive safety record of coal gasifiers. Even in the 1930s few accidents occurred in gasifiers, and with today's improved equipment, the chance of an accident occurring is even smaller.

Coal gasification, however, is not without disadvantages. Simple low-Btu gasifiers, such as the one being operated in the Twin Cities, produce a diluted gas which cannot be economically transported through a pipeline over long distances. Since a fixed-bed gasifier operates on the basis of air passing through coal in the retort, the extremely small coal chunks, called "fines," must be removed before the coal enters the retort, or the air flow will be impeded. Furthermore, large amounts of water are required by the gasification process. Unfortunately much of the coal found in the U.S. is located in the western part of the country, where water is scarce. And finally, coal gasification still requires coal and is, therefore, plagued by all the problems of coal mining.

If any one factor indicates that coal gas is the fuel of the very near future, it is cost. The price of coal gas is dependent upon a variety of conditions, the most important of which is the coal to be gasified. Since low-Btu gas is expensive to transport, most gasifiers are being built and will be built "on site," directly adjacent to the industrial gas user. This requires that the coal be shipped to the user's location. A relatively close source of coal is therefore necessary to avoid high transportation costs. The coal must also be a "compliance coal"—a coal with only small amounts of sulfur. Even though the sulfur can be removed with present technology, the cost of the gas nearly doubles when desulfurizing equipment is added to the system.

The load factor, the percentage of time gas is actually needed, is also very important. Donald Bliss, financial and administrative manager of American Natural Resources, a company which sells coal gas,



The gasification process.

summed up the situation as follows:

"We have a fixed cost. Once you start dividing that fixed cost by a lower number, the economics go out the window. We have to have a location where they [the users] are going to be operating as close to 365 days a year as possible."

Encouraging financial rewards await industrial users who can meet these requirements.

"We're looking at a plant in Louisiana right now," said Bliss. "We're talking about a $3.75 to $4.00 per million Btu's starting price in 1985. Natural gas in Louisiana is projected to cost, in 1985, somewhere around $5.00 per million Btu's."

And with natural gas prices going up, the economics can only get better. So why aren't more industrial facilities using coal gas right now?

"I'm surprised that there has not been more activity in companies investing and converting to coal gas than has occurred," said Maurer. "I think, however, the major reason for that has been the total, low economy of industry. Production has been down for the last 12 to 16 months. Money historically has been tight.... Industries are in a very uncertain, unsettled situation. I think there's a consistent thought throughout industry that coal is going to play more and more of a role, but no one is rushing to the forefront to make those conversions, other than possibly pulverized coal burners and stoker-type boilers. There's also an inertia factor which plays a very significant role. Industry is so slow to change, and even though it's an old process it's being applied to new processes in a new environment."

Still, the MIFGA group remains confident in the inevitable return of coal gasifiers to the American industrial scene. Proposals concerning the installation of a fluidized bed gasification system, modification of the cyclone, and the production of medium-Btu gas at the Twin Cities pilot gasifier are all being reviewed. A broad variety of coals and even peat will be gasified in 1984. A greater awakening to the benefits of coal gasification is expected on the national level, as expressed by Liu:

"Right now we're just in the middle of a special situation because the economic recession throughout the world and the energy conservation effort have reduced the demand for oil. But when the economy recovers, the energy demands will grow. We will have trouble with oil supplies in the future. Whether it be three or four years or ten or fifteen years, we will have problems. People will begin to look at the economically viable alternatives to oil, and one comes down to coal. We've got plenty of coal in this country. How do you use coal? You basically have two ways: you can burn it directly, or you can produce gas. If you burn it directly it is not compatible with certain processes.... Thus we have to use the energy in another form—the form of gas. The low-Btu gas has a special niche in the whole spectrum of coal utilization."

Not bad for an old workhorse from the '20s. ■

Randy Smith-Kent, a mechanical engineering graduate student, is often confused with his distant relative, Clark, who is also a reporter. Randy, however, insists that they have nothing in common . . . A large red, blue, and yellow cape was found in the *Technolog* dark room. The owner may claim it in ME #2.

Al Hauser is the editor of *Technolog*. He is currently working on a scheme in which Northrup Auditorium would be gasified and the gas sold to help *Technolog* through its financial woes.

The Graduate

A Twin Cities Guide to Interviewing

By Karen Auguston

"Don't take the 30 minute campus interview for granted; you may not have another opportunity . . ."
Mark Bailey,
Personnel Administrator, CDC

Minnesota's 10,000 lakes and miles of great bicycle paths are not the only reasons so many graduates of the University of Minnesota would like to remain in the area. Minnesota is also the home of a number of widely recognized high-tech corporations which employ many of our home-grown engineers. In this article *Technolog* examines the differences in college recruiting among area firms, and representatives of three local companies reveal their secrets of successful interviewing.

The corporate recruiters are back on campus, and seniors, eager and professional in three-piece suits and ties, have descended upon the I.T. Placement Office. The campus interview is a crucial part of the employment process. After four years of hard work, it is the tie between academics and employment. In today's tight job market, good interviewing skills have become increasingly important—the performance here will determine whether or not the candidate is invited back for a second interview.

Many hours in a lifetime are spent on the job—quite a few more than the relatively few hours of preparation necessary for a successful interview. Yet poor interviews are most often the result of inadequate preparation, the inevitable consequence of "not doing your homework." Competition for jobs is still strong, so one must endeavor to outshine the rest by polishing interviewing skills.

What is a campus interview? The interview is an exchange of information between the student and the company representative. It is the student's opportunity to get acquainted with the company, and the company's opportunity to evaluate the student. The interview is a sales pitch in which the candidate sells his skills and abilities. However, this is also an opportunity for the representative to promote the company. Competition exists among firms for the outstanding candidates, and companies must do a little selling themselves to attract these promising individuals!

The nature of the interview greatly depends on the background of the recruiter. Some companies are represented on campus by their personnel staffs; personnel people will inquire at length about relevant coursework and grades. If the interviewer, however, is a professional engineer or other technical person, the interview may focus on particular areas of the candidate's technical background.

Most of Control Data Corporation's campus representatives are members of their personnel staff who have been assigned to college relations. According to Mark Bailey, personnel administrator, Control Data Corporation, Bloomington, the main intent of a company recruiter is to identify potential employees for Control Data Corporation. It is the responsibility of the recruiter to represent the entire corporation and screen individuals for particular needs within the company.

John Field, manager of organization and staffing, represents ADC Magnetic Controls Company, Minneapolis. Mr. Field interviews with similar intentions: "I don't always know what our future needs are going to be, so I am looking for the most promising candidates in terms of a good fit with ADC. I don't know in advance where exactly they will be placed within the company." A professional in personnel and management consulting, Field would prefer the student save the "shop-talk" for the second interview. At that time, the individual will have an in-depth talk with company engineers.

Honeywell's campus representatives are managers and engineers within the department or division where openings exist. Because the candidate is judged on compatibility with a specific position, the recruiter may concentrate on one particular technical area. However, Dianne Flanagan, staffing representative, Honeywell Underseas Systems Division, Hopkins, adds, "If the recruiter feels the individual would be an asset to Honeywell [but perhaps not in the position for which he is interviewing], that student may be recommended for another area within the division."

Companies are always on the lookout for the superstars. These promising individuals are often "grabbed-up" by companies who know if they don't make an offer, someone else will. Although no real openings may exist, room can always be found.

Some companies stage very structured interviews. At Honeywell recruiters prepare for interviews with a list of suggested questions and topics. Students should be prepared to answer such typical questions as the following: "Why are you interested in Honeywell?", "Why did you choose engineering as your field of study?", and other questions relating to coursework and career objectives.

An interview with John Field might cover anything from the telecommunications industry to local health clubs. Personable and relaxed, Field does not interview the applicant, he has a conversation. His style is extremely effective, much to the chagrin of students who have said much more than they intended to say.

Mark Bailey of Control Data advises the student to avoid asking "patented" questions. He states that the student should tie questions about opportunities within the company in with comments about his or her background and skills, making them relevant. An honest and sincere interest in Control Data will result in the most effective interview.

All the companies with which we talked do some screening of candidates (usually by reviewing resumes) as well as offering open interview schedules. Mark Bailey points out that a company relying exclusively on this type of screening may be missing out on a lot of good candidates. However, not all students who wish to see a particular company on campus may get an opportunity to do so. Unable to obtain a slot on a company's interview schedule, individuals may also forward resumes directly to the company. If there is sufficient interest, an interview may be scheduled directly with the student. Bailey emphasized that students should not view campus recruiting as the only method of contacting area companies. "Students who do not talk with us on campus always have the opportunity to come knock on our door..."

It is important that the right people come together at the interview. However, with the scramble for jobs in recent years, students have been signing up with anyone they can see. Lee Ponto, director of the I.T. Placement Office, describes overhearing a student signing up for an interview: "Oh, here's a spot on this schedule. I don't know who it's with, but that doesn't matter..."

"We're interested in people who are interested in Honeywell," states Dianne Flanagan. Company representatives do not expect students to come to the interview knowing everything about the company, but candidates should possess an interest in the company and some knowledge about its operations. The student should have some idea of how his background ties in with the company, how his particular skills and abilities can contribute to the company's needs.

"ADC is in the telecommunications industry," adds Field. "I want to talk to those individuals who have an interest in that field."

Everyone seems to have a theory on the importance of the grade point average, but what role does it actually play in the selection process? All the representatives agreed that the GPA, while important, is only one criteria on which to judge a candidate. The importance of a good GPA depends upon the type of position for which the student is interviewing. "At our division of Honeywell, we are involved in extremely technical, state-of-the-art work, and consequently we view a good GPA as very important," says Dianne Flanagan. "However, we may be interested in students with leadership abilities and good communication skills for other positions such as marketing and sales."

"I don't like to hear a student apologize about a low GPA," stressed Field. "I will look at the individual's overall qualifications."

All the companies who recruit at the University of Minnesota do so because they have confidence in the academic programs and reputation of the University. "We're on campus with the confidence that all the students we interview are good candidates," declared Bailey.

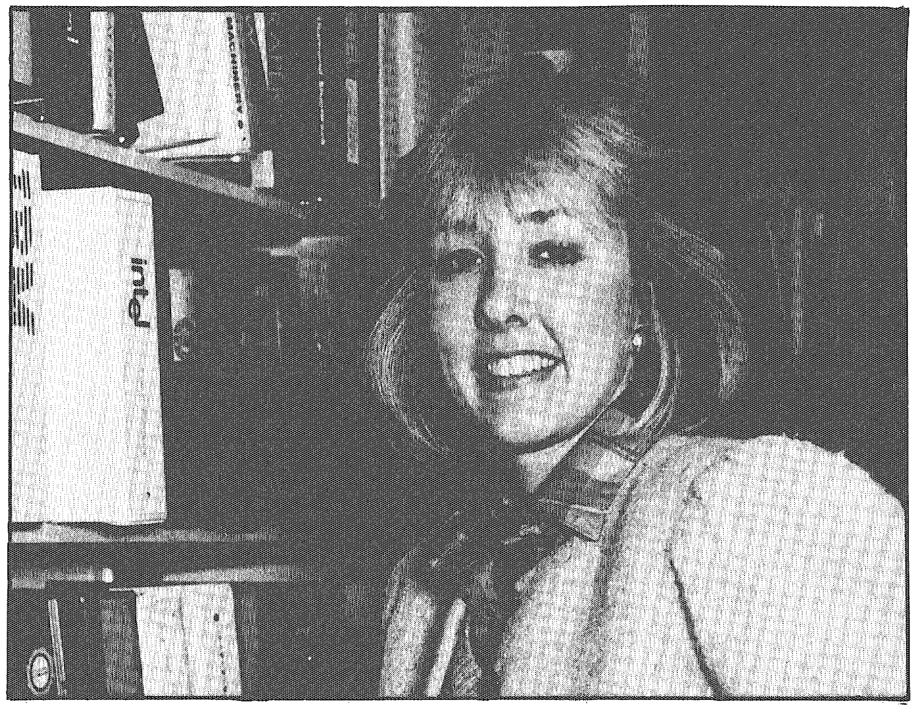
Which qualities separate the "great" candidates from the "good"?

According to Mr. Field a great candidate displays drive, sparkle and enthusiasm for the company and the position. "I like to find out something about the student, what he does in his spare time, whether he likes to whittle or play tennis. What interests an individual has tells me something about the kind of a person he is."

Mr. Bailey rated personality, experience and interests as important factors in judging the candidate. "Experience, whether it be intern, co-op or in the lab, gives the student a "hands on" familiarity with equipment and a better understanding of the work engineers are involved with. We want to know with what type of work engineers are involved. We want to know in what type of work a student is interested. Based on a candidate's interests, skills and experience, we can better determine where the individual may best fit into the company."

"Experience and expertise in areas related to the type of work we're involved in are very important," said Dianne Flanagan. "An individual who is diversified in his interests and confident in his abilities."

Mr. Bailey also urged students to



Karen Auguston looking through some of the many resources available at the I.T. Placement Office.

take advantage of the many seminars and services the University has to offer. "Seminars presented by company representatives are offered not only through I.T. but also through the School of Management's Placement Office. There is an abundance of resources available of which the student can take advantage, and we highly recommend doing so..."

Showing up on time, proper dress, alertness, enthusiasm, carrying a pad and pencil, being relaxed—all of these are essential elements of a successful interview.

Skillful interviewing means being prepared mentally, too. Self-assessment is extremely important. The candidate should have a clear idea and understanding of where he/she is heading in his/her career and be able to express well-defined objectives and goals. A candidate who believes in his/her talents and abilities will communicate this during the interview by accentuating the positive and striving to get his/her good points across.

What happens after the interview? The interview should be followed up with a note expressing an interest in the position and the company and thanking the interviewer for his time and consideration. If the interview has been successful, (and we're assuming having read this, it will be) the recruiter will pass his recommendations along to individuals within the company who may have needs for that candidate's particular skills and abilities. If a need exists and a match is identified, the individual is notified and invited in for a plant tour and a second and perhaps third and fourth interview. After enough interviews an offer is usually made and accepted. The result—another lucky engineer living and working in beautiful Minnesota!

Then cold reality sets in—the harsh months of winter, when Minnesota's 10,000 lakes are mostly frozen over and bicycle paths are under five foot drifts of snow. Keep the names and addresses of old classmates who accepted job offers in Southern California handy... San Diego is heaven in January! ■

Special thanks for information used in this article to:

Mark Bailey, Personnel Administrator, Control Data Corp., Bloomington.

John Field, Mgr. of Organization & Staffing, ADC-Magnetic Controls, Mpls.

Dianne Flanagan, Staffing Rep., Honeywell Underseas Systems Div., Hopkins.

The Illuminated Vortex

Understanding how the in-cylinder flow of the fuel-air mixture is influenced by chamber geometry provides a key to improving engine performance. By applying a laser measurement technique, a researcher at the General Motors Research Laboratories has gained new insight into the behavior of the flow.

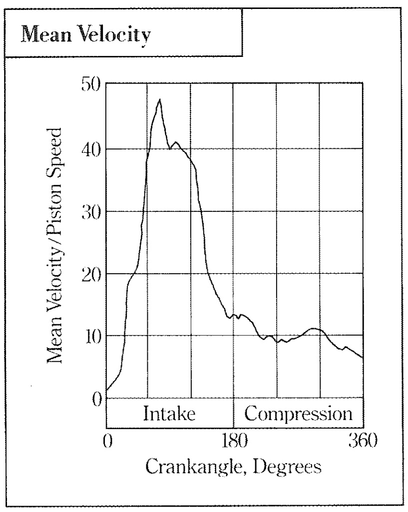
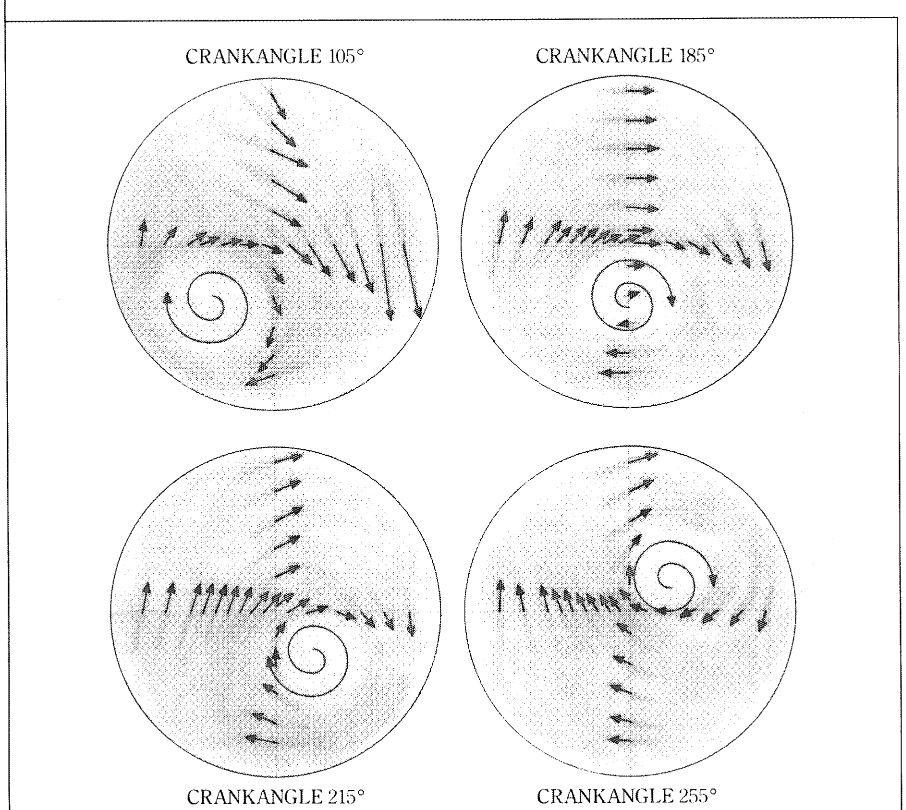


Figure 1: History of mean velocity at a single engine location.

Figure 2: Panoramic view of engine flow patterns. With changing crankangle, the center of rotation precesses from the cylinder's lower left quadrant to its upper right quadrant.



THE FLUID motions inside engine cylinders have considerable influence over the progress of combustion. Mixing of air and fuel, combustion rate, and heat losses from the cylinder are all important transport processes strongly dependent on fluid motions. The motion inside the cylinder has two components. Mean velocity influences the transport of momentum, energy, and species on a cylinder-wide scale, while the turbulence component influences the same phenomena on a local basis. The in-cylinder flow field depends primarily on the geometry of the cylinder and inlet port. Hence, decisions made in the engine design stage exert a controlling influence over the flow. But before questions about how different geometrical features affect the flow field can be answered, the problem of how to measure the flow must be solved. By applying Laser Doppler Anemometry (LDA), Dr. Rodney Rask, a researcher at the General Motors Research Laboratories, has obtained detailed measurements of the flow field.

LDA is a technique in which two focused laser beams pass into the cylinder through a quartz window. In the minute measuring region where the laser beams cross, a regular pattern of interference fringes is created. As the 1-micron particles, which have been added to the engine inlet flow, cross the measurement region, they scatter light in the bright fringes. In Dr. Rask's LDA system, the scattered light is collected by the same lenses used to focus the laser beam, and measured by a photomultiplier tube. The resulting signal is processed electronically to determine the time it takes a particle to traverse a fixed number of fringes. Since the fringe spacing is a known function of the laser beam crossing angle, this transit time provides a direct measure of velocity.

During operation of the LDA, measurements of velocity as a function of engine rotation (crankangle) are made at a number of locations within the cylinder. The instantaneous velocity at each point must then be separated into mean and turbulence components. The simplest technique is to declare that the mean velocities for all cycles are identical and ensemble average the data. However, this approach ignores the cyclic variation in the mean velocity. Another technique looks at individual cycles and uses a variety of methods, including sophisticated filtering, to split the instantaneous velocity into its components. This approach is consistent with the LDA measurements, which clearly show that the mean velocity does not repeat exactly from one engine cycle to the next.

Differences in the flow field from one cycle to the next can seriously compromise engine efficiency. Near the end of the compression stroke, it is important to maintain a consistent velocity at key cylinder locations (e.g., at a spark plug). Dr. Rask's LDA measurements have identified design features that control cyclic variability.

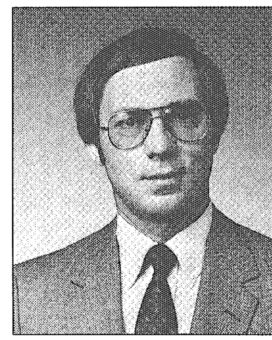
FIGURE 1 shows mean velocity measured at a single location during an engine cycle. High velocity exists during the intake stroke when the inlet flow is rushing through the narrow valve opening. This jet-like flow into the cylinder causes large velocity differences between adjacent cylinder locations and produces strong turbulence. As the end of the intake stroke is approached (180 degrees in Figure 1), the levels of both mean velocity and turbulence drop rapidly. This decrease is a result of the changing boundary conditions for the cylinder—from strong inflow to no inflow. During the compression stroke the flow field evolves, but it undergoes no drastic changes. However, in a high-squish chamber, where the flow is forced into a small bowl in the piston or cylinder head, considerable turbulence is generated near the end of the compression stroke.

Measurements from many cylinder locations are necessary to make the flow field understandable. Figure 2 shows four flow patterns covering a period from near the end of intake into the compression stroke. Note the strong vertical flow, with the center of the vortex away from the cylinder center and precessing with changing crankangle.

By experimenting with geometrical variables, Dr. Rask has gained new understanding of phenomena observed in operating engines. The resulting knowledge has guided the design and development of new engines with a minimum of trial-and-error testing. The LDA findings are also being used to validate and calibrate engine flow computer models under development.

"From our measurements," Dr. Rask states, "we have been able to deduce how changes in the geometry of the port and combustion chamber modify the velocity field. These flow field effects are now being used to help designers tailor engine combustion for optimum performance."

THE MAN BEHIND THE WORK



Dr. Rodney Rask is a Senior Staff Research Engineer in the Fluid Mechanics Department at the General Motors Research Laboratories.

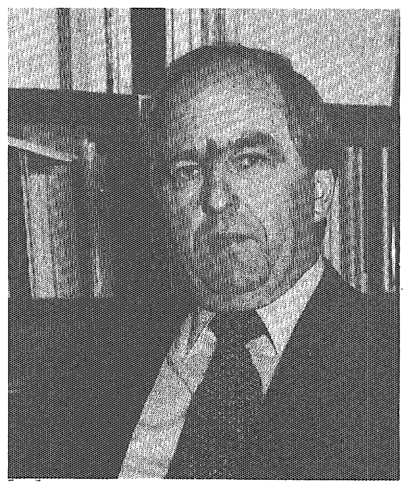
Dr. Rask received his undergraduate and graduate degrees in mechanical engineering from the University of Minnesota. His Ph.D. thesis concerned the Coanda effect.

Prior to joining General Motors in 1973, Dr. Rask worked on the design of nuclear reactors at the Knoll's Atomic Power Laboratories. In addition to further refinements in LDA measurement techniques, his current research interests include computer simulation of engine systems, with special emphasis on the intake manifold.

I.T. Talks About Nuclear Power (Part I)

By Randy Smith-Kent, Curtis Heiserman, Jan Fransen, and Mike Pateyuk

In recent years few areas have generated as much controversy as nuclear power. While the Three Mile Island accident has led to a virtual halt in the purchasing of new nuclear power plants, both positive and negative sentiments can still be found among the general public. *Minnesota Technolog* interviewed six I.T. professors in an attempt to discover how they felt about nuclear power. Excerpts from these interviews are printed below. In Part II of this story, the results of an I.T. student survey will be given.



Dr. Arthur L. Norberg, Department of Computer Science. Dr. Norberg worked for Westinghouse in the middle 1960s, where he studied reactor lifetimes. He is currently director of the Charles Babbage Institute.

Economics . . .

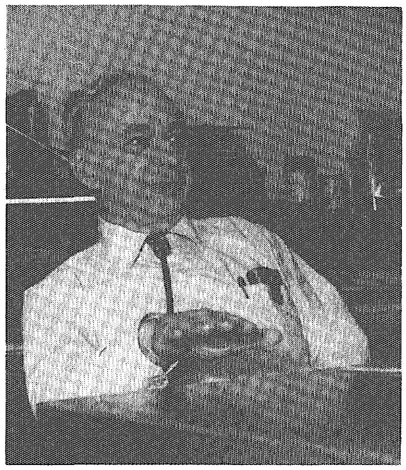
"I think economically it [nuclear power] is a failure. I think it cannot compete economically. Many of the arguments, in the early years, were based on its economic value. I remember when I first went to Westinghouse in July of 1963. [A high official] introduced us to the topic of the importance of nuclear power to the nation. I remember some rather outrageous quotations for cost per kilowatt hour of nuclear power. At the time I had no reason in particular to question it. I did not know that much about it from a cost point of view. I thought about it and discussed it with some of the other people in the office and learned quite a lot about the assumptions behind the figure."

Waste disposal . . .

"The best I can say is I have followed the various reports put out by, most recently, the National Academy [of Science] and the Office of Technology Assessment, and the assumptions that the Department of Energy is making still seem to me to be the same as they were making in the 1960s about corrosiveness, about strength of materials and about the type of barrier needed to keep these things contained. The DOE is still talking about salt mines as the half life curve progresses. They are still talking about the type of materials that can be used under those conditions, like glass, silicon . . . and I just think that it is insufficient. They are going down one pathway just as we did in the early 1960s. One pathway for the construction and transfer of these products, and I think it is unsafe."

Moral implications . . .

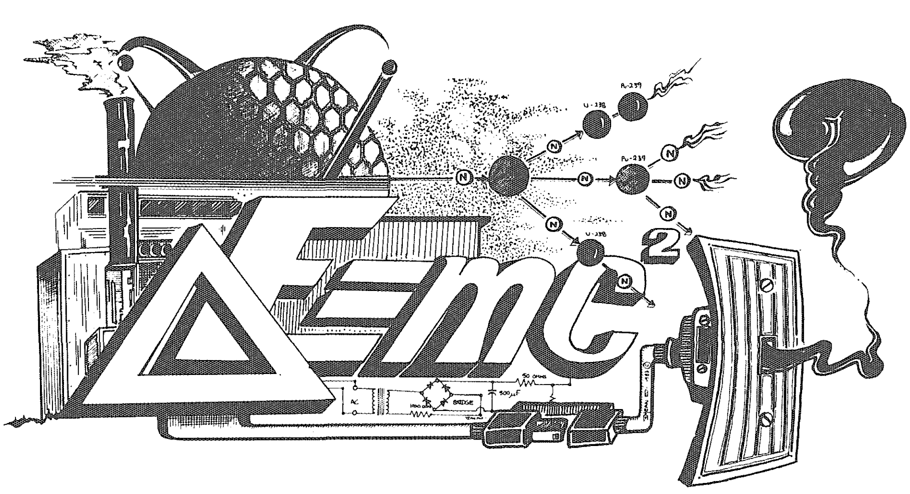
"The moral issues . . . have to do with what we are committing future generations to because of the way we are handling the waste products. I think that if we agree that we are going to develop nuclear power, along with the consequent long-term problems associated with it, that it is alright. But you have to accept the responsibility you have to future generations. Normally we don't have that responsibility."



Dr. Kenneth T. Whitby, Department of Mechanical Engineering. Dr. Whitby has been involved with various committees dealing with nuclear power in the past and is currently serving on the American Physical Society Study Committee on the Reactor as a Source Term.

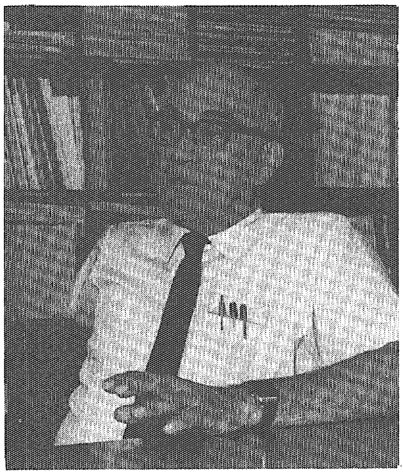
Public perception . . .

"One of the real problems of public perception and public policy . . . is the problem of concentrated impact of a technology verses distributed gain. That is what the problem of the nuclear reactor is. From what I know about the safety of nuclear reactors, there almost certainly are going to be more accidents. I don't go along with the people who say . . . this can't happen. Three Mile Island proved them wrong. Those of us who were involved in the '60s never thought that. I never did. What happened at Three Mile Island was inevitable as far as I was concerned. In fact, I wish it had happened ten years sooner. It would have done us a service. In fact, in some ways Three Mile Island was a service to the whole business. But, on the other hand, I do not think the consequences of this are going to be anywhere near as serious as what many of the antinuclear people, whose imaginations run wild, think they're going to be. But the fact remains that a reactor is a big thing. It has got to be put some place where there are people. When this happens it is going to impact some people, and it may impact them in a pretty bad way. The same thing occurs when an airplane goes down, or when a hotel burns . . . Now, a coal-fired plant, on the other hand, has a different kind of impact. From what I see, the total damage done by a coal-fired power plant over its entire lifetime to the general environment is considerably greater by leaps and orders of magnitude than a nuclear plant. But it is spread all over, and in lots of cases, it is somebody else's country, somebody else's state, somebody else's river, or somebody else's lake [which is damaged]. So who needs to worry about that? Well, you can talk all you want, but people think 'out of site, out of mind.' From where I sit, the damage that is going to be done by generating all of this electric power with coal power plants is going to be considerabnly greater than the damage that is going to be done by nuclear plants, but the problem is, with the nuclear plant, the sudden catastrophe can happen in a particular place and is going to have a big impact on a small segment of the population."



The future . . .

"I am quite sure what will happen . . . I think, with the current [political] climate, there are going to be very few, if any, nuclear reactors built in the United States . . . But in about 10 or 15 years the energy crunch will really get to be a crunch. We haven't seen anything yet. That's when the world starts running out of oil, that's when we find out that—talking about all of the free solar energy—we can't make enough of it no matter what we do to maintain the current rates of consumption, or even a fraction of it. Then what do we do? Do we build horrendous quantities of coal plants? You've got other problems there, too. If you try to replace natural gas and gasoline with synthetic fuels you soon find that these are carcinogen factories. They make really nasty stuff by the tons. They are going to make coal-fired power plants look like pussy cats. If you think we have environmental problems with coal plants, you ought to start thinking about some of the environmental points concerning making liquid and gaseous fuels from coal. I think what will happen is when this crunch really comes, in about ten or fifteen years, there is going to be a vast reassessment by an awful lot of people. The old nuclear reactor will look pretty clean and tame early in the next century."



Dr. Alfred O.C. Nier, Department of Physics. Dr. Nier has worked on the development of the mass spectrometer and was the first to separate U-235/U-238 using a mass spectrometer. He has been on numerous nuclear power committees.

Compared to coal . . .

"I think there are a lot of advantages [to nuclear power]. One of them, probably the most important, is that it's safer . . . From an overall standpoint, I think it's safer than coal. I say this for a number of reasons. First of all, unless the coal plants are greatly improved, so far as material thrown up into the air is concerned, there are and will continue to be a lot of health problems. It is estimated that something like ten thousand people in this country lose their lives each year due to the burning of coal. I'm not talking about coal miners; about one hundred coal miners per year lose their lives due to normal accidents. I'm talking about the man on the street.

"Another real advantage to nuclear power, and it's just showing up now, is that [it is free from] all of the fuss being made about acid rain, which comes as a result of coal burning and automobiles and fossil fuels in general. You don't have that problem with nuclear power because the stuff it puts in the air is harmless.

"The third advantage, which is just coming out now, is that the burning of fossil fuels increases the carbon dioxide in the atmosphere . . . You can improve power plants by putting more and more expensive filters in the stacks to take out the sulfur dioxide, but you can't do anything about the carbon dioxide, so you have to release it. There is great concern that there will be climatic changes of a very drastic kind within the next one hundred years."

Economics . . .

"The fact of the matter is here [Minnesota] we are very fortunate that our electrical costs are very low, thanks to the foresight that Northern States Power had in producing nuclear power. Almost half of their power is produced by nuclear plants at Prairie Island and Monticello. That is one reason our electric rates are so low here. They have a very efficient arrangement. The company is sound financially because of the low cost [of nuclear power] . . . I've just returned from France, and the whole country depends on nuclear power for 50 percent of its needs. They don't have much in the way of fossil fuels, so they hope to go to 80 or 90 percent nuclear."

Waste disposal . . .

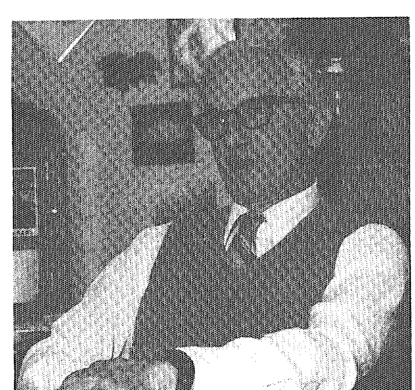
"The real problem with nuclear energy, at the present time, is that the power companies have been put into a box on disposal of nuclear waste. The government was supposed to take it off their hands. They take the fuel rods out of the plants at regular intervals, about every six months, and replace about one-third of them. They are being forced to store them locally. They have a big pool . . . about as big as a swimming pool you'd find in a YMCA. All of the waste material is stored in this pool.

"What should be done, from a technical standpoint, and this is what is going on in France now, is the uranium and plutonium should be reclaimed from the spent fuel. What remains are the fission products. The fission products are the things we need to do something about; that's what the real issue is. Now, the problem that the government has been unwilling to face for reasons that are partly legitimate is that . . . one can separate the plutonium . . . and with it make bombs. Why they [the government] are afraid of this I am not sure because they have plants that make plutonium for making bombs. If they are not worrying about that [plutonium] disappearing, they need not worry about the spent fuel rods."

Dr. Archie S. Wilson, Department of Chemistry. Dr. Wilson was an undergraduate research associate on the Manhattan Project from 1943 to 1946 at Iowa State University. He has also worked on plutonium separation processes for General Electric.

Compared to coal . . .

"I personally think that the chemical problems with coal are more easily solved than the nuclear waste problems. Just taking the sulfur out of the coal with limestone or the other various processes is costly, but energy is costly, and it becomes more costly as time goes along, as the easily obtainable energy sources are depleted. People wouldn't object to storing a little calcium sulphate in drums. Calcium sulphate is harmless. But they do object to storing radioactive wastes, even low level wastes."

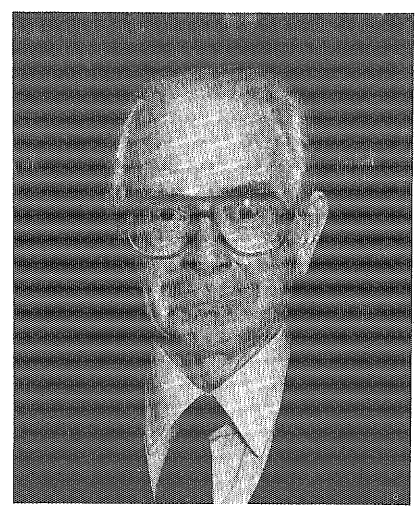


Waste disposal . . .

"Processing the fuels was part of the cycle. The fuels were to be dumped out of the commercial reactors, cooled for some period of time so the short lived activities would die off and the fuel cooled down, then transported to a separation plant, where the separation plant would separate out the uranium and the plutonium and the fission products. The plutonium could be used in some sort of breeder reactor. That cycle has been shut off, and we are approaching a crisis. In fact, I think in some places we are already at the crisis stage. Those fuels are loaded into large, what we call 'swimming pools,' where they are stored underwater. Water is used because it is a nice coolant, a way to get rid of the heat, and it offers protection against radiation to the workers. The swimming pools are filling up, and now we have to decide whether we are going to build more swimming pools or simply increase the number of fuel elements per swimming pool. People worry about that because of the possibility of an accidental critical incident . . . So the nuclear industry is at a crisis stage because of the national policy of not processing these [fuel rods]. Processing them and then taking the concentrated waste and putting it where it won't get back in to the environment [was the goal]. That sounds fine on paper, but when you try to put that together, it doesn't work. People don't want this stored in their backyard. 'Not in our back yard' is the way it's put."

Economics . . .

"It's turning out not to be the great energy savior that all of us thought when we were younger and perhaps more optimistic about things. When I was working on the Manhattan Project, one simply made that simple calculation, how much mass is equivalent to how much energy, $E=mc^2$, and obtained fantastic amounts. And those were all of the comparisons we had in mind. Now, getting that energy out in some useful fashion so that we can do things with it has turned out to be not as easy as we all imagined. Some of the earlier statements, where the energy would be so cheap that we could do away with meters—well, that obviously hasn't worked out."



Dr. Herbert S. Isbin, Department of Chemical Engineering. Dr. Isbin has been involved in nuclear energy for more than 30 years, both from the standpoint of teaching and research. He has participated in local and national regulatory groups and is nationally known as an expert on nuclear power.

Dr. Terrence W. Simon, Department of Mechanical Engineering. Dr. Simon worked for six years with General Electric, the builder of nuclear steam supply systems.

Reprocessing and transport . . .

"There are two big ones [problems], I think. One has to do with reprocessing. They [utilities] were building plants and mining and processing uranium with the expectation that sometime in the future the full uranium cycle would be developed, which includes reprocessing—things like plutonium recycling and things of that nature. They were pretty far along and found that reprocessing wasn't as easy as they thought it was going to be. This is after they had some plants running for ten years. They also found that plutonium recycling wasn't as popular or acceptable to the public as they had anticipated. So suddenly all of these rather crude and sketchy plans that they had for these plants that were operating for ten years began to fall apart. They really had no good idea what they were going to do with all of that spent uranium, and they still haven't figured out what to do with it. It was a matter of being a little too anxious to get the product out and generating revenue without sorting out the problems. The other part of the problem, and it is just as serious, has to do with the transport of uranium . . . I think that it was something they weren't too concerned about. They probably thought it would fall into place. The idea of actually having weapon-grade fuel around—the political implications and the national security implications—kind of caught them off guard. They were in the power business."

The future . . .

"Technically I don't see the problems as insurmountable, but the social situation, the acceptance, is insurmountable. I don't think that nuclear fission is going to do that much."

Safety . . .

"I believe, based on my experience and involvement, that nuclear power plants can be operated safely but that this requires a dedication and a commitment. One cannot ever be complacent about nuclear power. One must have the day-to-day and the long range planning that is necessary to sustain safety. But indeed, plants can be operated safely and effectively.

"The 'what if' approach is relatively new as far as engineering is concerned. Engineering in the past was based upon the establishment of safety margins based on prior experience. Here one is trying to anticipate dire consequences. One wants to make very prudent and conservative allowances for certain features which one may not fully understand. There are always questions to the extent of one's knowledge. We may be very competent in what we do but still there is some uncertainity. This is an ongoing process. As new information and new experiences arise, one tries to benefit from them. It continues to be a learning process. The degree to which safety is being improved becomes marginal in time, but certain changes can be made which give one a safer operation. I think that if the public had a better appreciation for the care and the scrutiny of this ongoing process, they would feel confident in the use of nuclear power. Unfortunately, we hear only of the difficulties and the problems, sometimes without reasonable perspective being given to these problems."

Technolog mailed surveys to all the professors in I.T. The 110 responses received are summarized in Figure 1. The last question asked was, "What do you consider to be the most major disadvantage of using nuclear power as an energy source?" The most common reply was "waste disposal," although responses varied. It should be noted that a more in-depth survey would be necessary to draw solid conclusions about the overall feelings of the faculty, since yes/no questions are too simplistic to deal with such a complex topic. Just as a wide range of opinions on nuclear power can be found in any sample of the general public, *Technolog* found diverse views among interviewed faculty. This disagreement is merely a reflection of the true complexity of the nuclear power problem. ■

QUESTION	NUMBER	PERCENT
1. *How should US proceed with nuclear energy?*		
Proceed rapidly	20	18.2
Proceed slowly	64	58.2
Halt development	15	13.6
Dismantle plants	11	10.0
?	1	.9
2. *Are the risks of operating NP plants acceptable?*		
Yes	78	70.9
No	27	24.5
?	5	4.5
3. *Would you be willing to live near a NP plant?*		
Yes	71	64.5
No	34	30.9
?	5	4.5
4. *Do we have enough knowledge to solve the problems facing the nuclear industry today?*		
Yes	64	58.2
No	37	33.6
?	8	7.3
5. *Do you feel that present NP plants are unsafe?*		
Yes	41	37.2
No	60	54.5
?	9	8.1
6. *Pick three of the following which you feel will make the greatest contributions to our energy needs by the year 2000.*		
Biomass	6	
Coal	82	
Conservation	51	
Geothermal	2	
Natural gas	41	
Nuclear fission	41	
Nuclear fusion	10	
Oil	50	
Solar	12	
Synthetic fuels	9	
Wind	6	

TOTAL RESPONSES: 110

Figure 1

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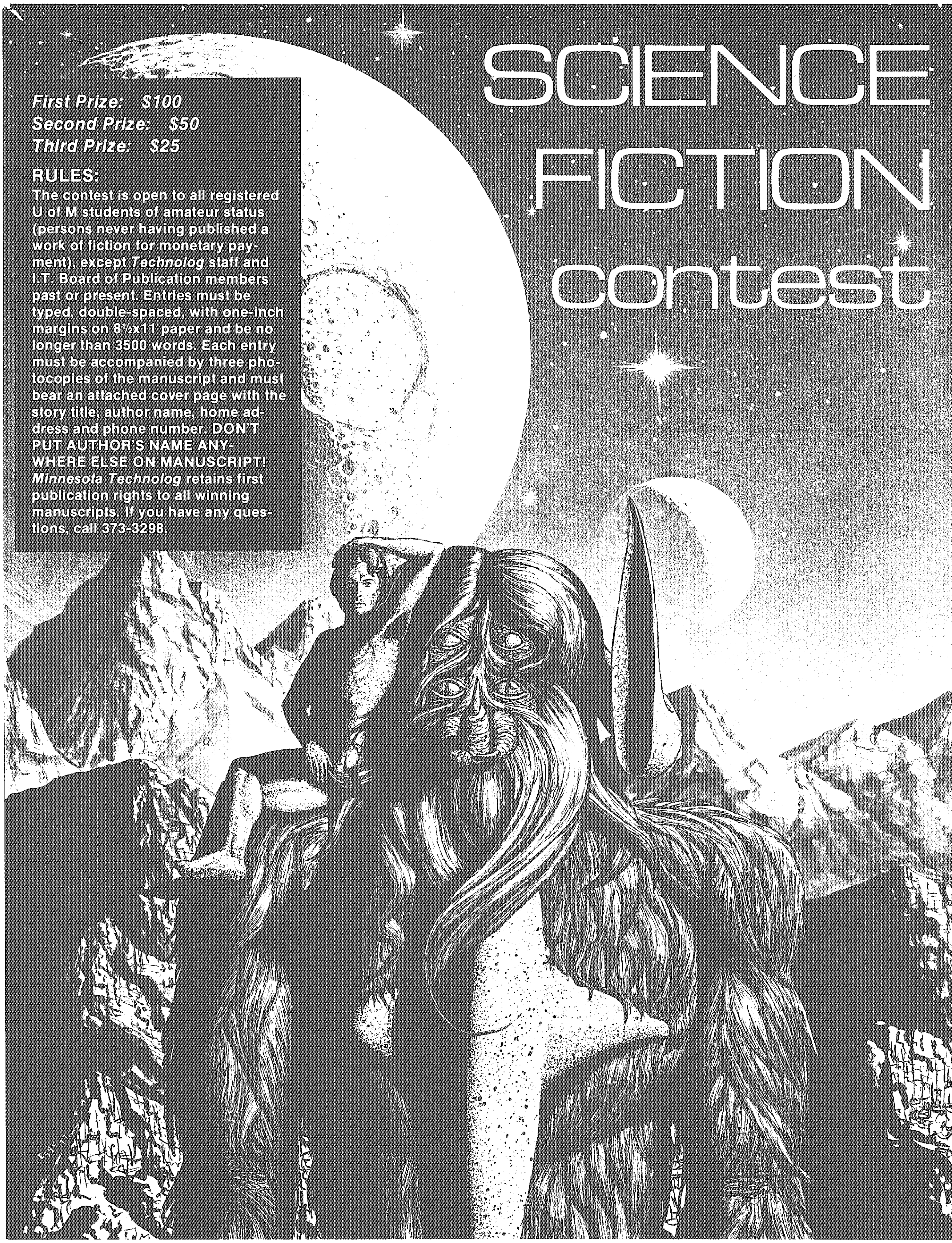
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Ad Astra

By Scott Otterson

Touch The Stars: Emergence, John Dalmas and Carl Martin, A Tor Book, paperback, 318 pages, $2.95.
Laws Of The Game, Manfred Eigen and Ruthild Winkler, Harper, paperback, 337 pages, $8.95.

It would be interesting to find out why it took two authors to write ***Touch The Stars: Emergence,*** by **John Dalmas** and **Carl Martin.** Since the fruit of their efforts is nothing more than a standard space western, one hopes that the object of their collaboration was to produce in quantity not quality.

Jason Roanhorse, an Apache Indian living in Scotland, is a great captain of 21st century industry. As the owner and chief executive of the world's foremost aerospace firm, Roanhorse is an important global figure, and nations compete for his favor. Like 90 percent of all poorly developed science fiction characters, he is fiercely competent at everything he does, be it designing the latest fighter engine or rounding up a herd of stampeding cattle. And like the rags to riches capitalists of Horatio Alger stories, he is also morally pure. That is why he will not join the sinister Hamilton Club, an association of rich robber barons who have been secretly manipulating the masses into wars and depressions since the 1880s. The Hamiltonians are bad men. They beat up little girls and want to take over the world. That is why they decide to convince the Russians—who are also bad—to nuke Roanhorse out of business after he develops faster-than-light transportation and turns down their invitation to join with a nasty letter.

So much for a credible plot.

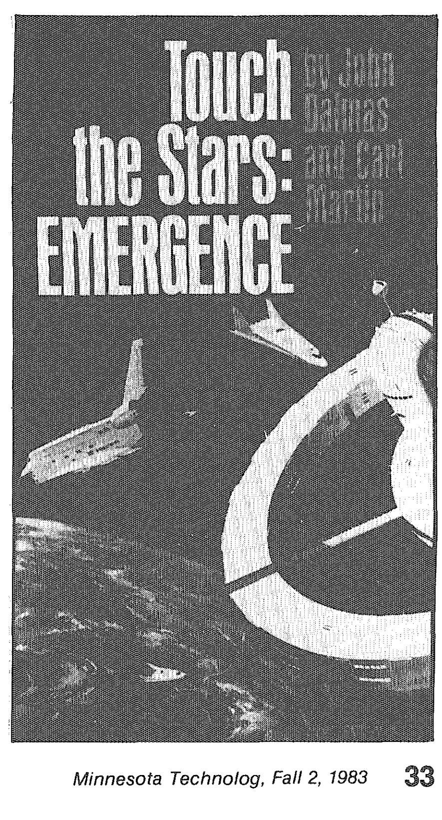
Actually, a big part of the problem with *Touch The Stars* is that there is too much plot. Roanhorse careens around the world, grinning, shaking hands, and exuding magnanimity like some used car salesman's idea of a messiah. He closes so many business deals and does so many visionary things (like authoring the first interplanetary trade charter) that there isn't much room left for a story. Oh yeah, man has discovered life on another planet, and Roanhorse will be the first person to meet them. In the middle of the book he catches a faster-than-light flight out to a planet of little men and women that wear double-breasted suits and fedora hats. I'm not kidding. Nothing much happens, though, as it is only an exploratory mission, and everybody heads back to Earth for more action and adventure. Incidentally, Roanhorse's pre-teen son tries to sneak aboard one of these exploratory missions in a laundry bin but is discovered. As punishment, he is confined to the ship as a dishwasher. A dishwasher? In the 21st century? On a space ship? C'mon!

Needless to say, *Touch The Stars* is a silly book and I don't think I will wreck much suspense by letting on that Roanhorse avoids nuclear evaporation by setting up his headquarters in one of his faster-than-light ships. He does, however, have a falling-out with his wife who has to leave her potted plants behind.

For more literature of this kind, go to the local drugstore comic book rack.

Another product of two authors is a new German to English translation of ***Laws Of The Game,*** a sprawling essay on the metamorphosis of order out of randomness by **Manfred Eigen** and **Ruthild Winkler.** Using traditional and newly invented games of chance to illustrate applications of probability and number theory to, among other things, statistical mechanics, genetics, language, and music, the authors wander among and cross-pollinate so many ideas that the answer to the question of what this book is about is simply "everything."

Computer and dice games are presented so that, in spite of their dependence on chance, they produce stable equilibrium patterns; for example, a pattern of beads moves around a playing board in a characteristic way even though the moves of its individual beads are determined by the throw of a die. Some of these patterns are defined by certain rules used to play the games, others are dependent upon initial conditions, and sometimes



there is no way of telling which of many particular stable patterns will form. The fascination of order evolving out of chaos makes these exercises interesting in themselves, but it all seems pretty esoteric until the authors spell out the games' connections to the real world.

Bead games are used to mimic the evolution of the genetic material, RNA, and they suggest that the particular configuration that inhabits almost every cell in our bodies is only one of many possible stable configurations and that it was chosen randomly at some time in the primordial ooze. Physical laws forced evolution in the direction of the most stable configurations, but chance chose the winner. The authors observe that "Darwin's principle [of survival of the fittest] is reduced to the tautology 'survival of the survivor.'"

Games are used on a larger scale to demonstrate population genetics and world population growth. It turns out that human population growth is not merely exponential but is hyperbolic. Besides the fact that the oceans would fill with humanity if the trend continued for another forty years, what difference does this make? An involved argument, complete with computer simulations, shows that if the hyperbolic growth population (the third world) reaches a critical size, then its members will be automatically selected at the expense and eventual extinction of all other members, regardless of their "selective superiority." This section of the book is vaguely unsettling since it never makes clear who the "superiors" are or by what criterion they are superior. There seems to be an underlying and possibly racist assumption that the third world is inferior.

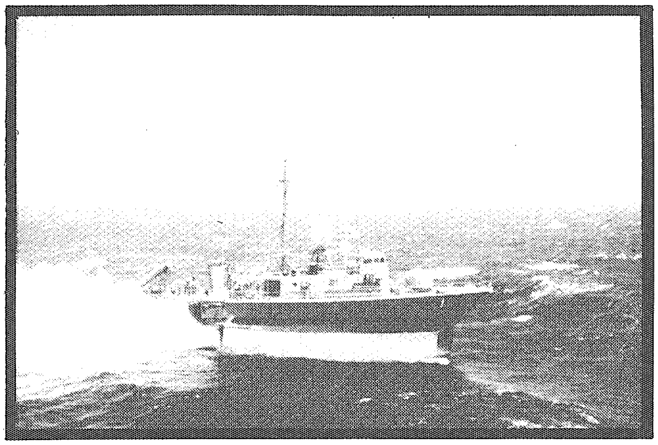
Some of the most interesting ideas in *Laws Of The Game* are not straightforward applications of statistical theory but unexpected combinations and analogies. After an arduous section on thermodynamics, the authors compare energy levels in matter to the information content of words. They then take this analogy to the next logical step and compute the entropy of a sentence. The curious reader will note that the entropy of a sentence can be reduced by fifty to seventy percent with knowledge of the language in which it was written.

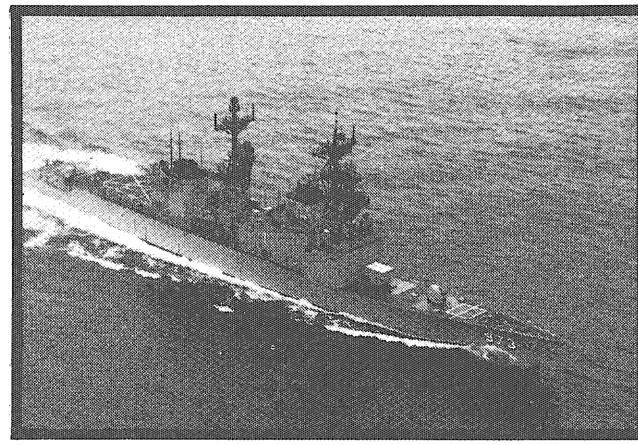
The temptation to make analogies in the political and philosophical realm was too great to resist. Arguments are made against both dialectical materialism—the Marxist philosophy that claims that physical laws will deterministically drive the world political machine to (surprise!) Marxism—and existentialism—the philosophy where nothing makes sense because the world is absurdly random. The authors argue that the world is not deterministic because chance makes for many "stable states." Nor is it absurd since physical laws channel living matter in a definite direction.

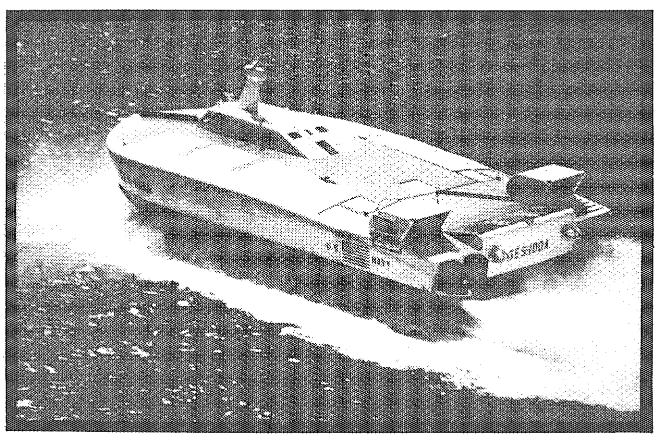
In a sense they are mixing their units, using scientific arguments against political/philosophical positions, multiplying force by distance and getting the Ten Commandments. In another sense, they are merely fighting fire with fire,

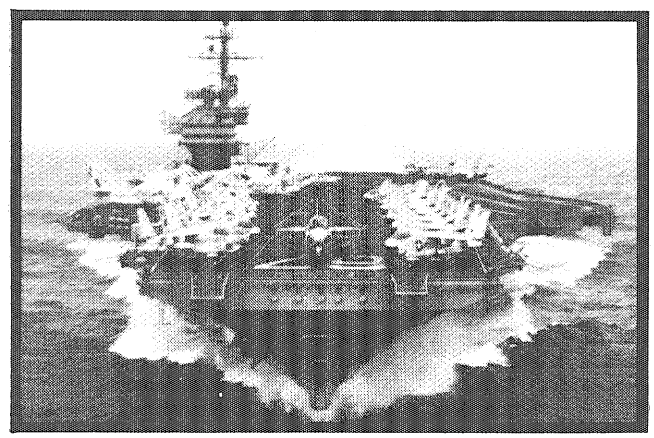
Continued on page 44

LEADERSHIP AND MANAGEMENT EXPERIENCE UNEQUALED BY INDUSTRY.... WHERE?









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THE NAVY

A Visit With Dean Murthy

By Michael Sorensen
Al Hauser

Dr. V. Rama Murthy was appointed acting dean of the Institute of Technology last spring following former Dean Staehle's resignation. Murthy had been head of the Department of Geology and Geophysics before becoming associate dean in April 1983 and, finally, acting dean in May. He will remain in this office until a permanent dean is hired, probably next summer. *Technolog* visited Dean Murthy in his office earlier this quarter.

Technolog: What will be I.T.'s number one priority within your year as acting dean?

Murthy: Let me backtrack a bit. We have made a very detailed programmatic plan for I.T. which has been accepted by all the departments in I.T., the dean, and the University's central administration [the president's office]. Part of that plan is to strengthen our engineering programs, in particular the Electrical Engineering and Computer Science Departments. These are the most heavily over-loaded departments, they're of the highest relevance to the state of Minnesota, and they're the ones we have not adequately funded with respect to load. Our approach to the legislature, the lobbying that went on, the public statements we have made, all concern the strengthening of these programs. Most of what I've been doing is simply following our plan, because it is our collective plan, not any single person's plan.

Technolog: Can you explain what you mean by "strengthening" these programs?

Murthy: Yes. For example, there are a number of highly relevant areas in Computer Science which are not adequately represented here: computer software development, large scale computers, artificial intelligence, robotics, areas such as these. It's mostly computer based activity, but relates to other departments, such as Mechanical Engineering and Electrical Engineering, as well.... These are areas where we will be adding resources, adding new faculty members, enlarging T.A. [teaching assistant] support, so that good graduate programs can go on and teaching functions can be performed [by the T.A.'s] as well. The problem with teaching is, in Computer Science for example, there has been a 90% increase [in enrollment] over the previous 2 to 3 years. Well, we haven't changed the support structure, so either the program suffers, or students get, well, not really high class instruction, or the faculty research suffers. Something has to go, and that makes us worry because once this happens you don't have a first rate department any more.

Technolog: What is being done to reduce overcrowding in I.T. in general?

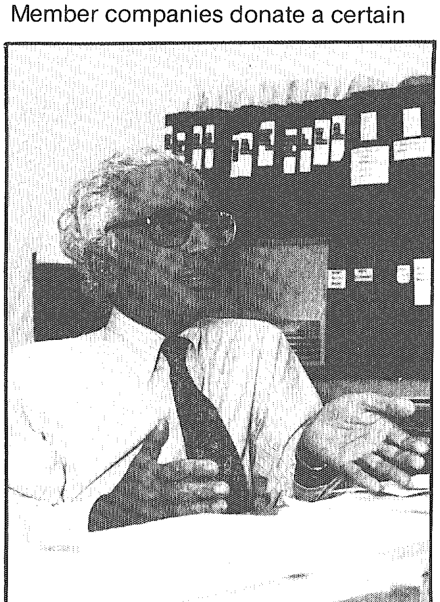
Murthy: I.T. has, by far, the largest share of appropriations this year, both from state legislative sources and from internal reallocation through central administration. The planning cycle caused reallocation and retrenchment in some areas which created a pool of money that was given to I.T. We had $250,000 given from the University internally, and $250,000 from the state legislature specially earmarked for teaching assistants. Since the overload problem is primarily in beginning [freshman and sophomore] sections of classes... that's where we'll use most of the T.A. money. So we have added new resources very clearly in these overloaded departments. In addition, the legislature has given $500,000 for new faculty, which will be coming in 1984. All of that money goes directly into 2 or 3 departments that have been singled out for support: Electrical Engineering, Computer Science, Mechanical Engineering.

Technolog: Former Dean Staehle believed that I.T. must establish a close relationship with the business community. What are your thoughts on this?

Murthy: Dean Staehle made a tremendous advance in our relationship with the business community. I strongly support this. We have been reaching out to all business chief executives to tell them what the University is about, what it does for the community, and how they should invest in the University, because business is an added resource. So I'm simply keeping the momentum going that has been created by Staehle. I think he did a remarkable service to I.T. and to the University. I strongly endorse his personal philosophy. We are still keeping in close touch with those members of the industrial community that want to work with us to solve problems of education quality and output of adequate numbers of University graduates for manpower which is needed in the state.

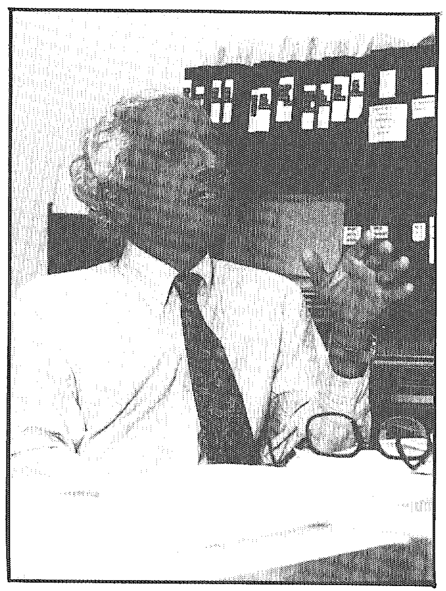
Technolog: Will this increased dependence on business and industry affect the type of research conducted at the University? That is, does the funding money have strings attached?

Murthy: I don't think that this is happening, at least in the examples I know now. We do have a substantial amount of industrial money coming into I.T. In some cases it must be used in specific areas, specific to a field, that is. But that spans both applied and basic research. Take, for example, the Microelectronics and Information Sciences Center. Industry has put in a lot of money, $6,000,000 total, which must be used for study in the microelectronics field. That is specified. But in order to make a major breakthrough in microelectronics, you need a lot of basic research in material science, chip technology, in software development, all of which is normal, basic science work. If industry hadn't come in, we would have gone to N.S.F. [National Science Foundation] to do this kind of work. In Minnesota the companies are fairly well advanced technologically. They're not asking us to help them simply increase production, they're asking for major breakthroughs and advancement in certain fields. Another way money is coming in is through the Partners Program, which is purely discretionary money. It is not specified where we use it. Member companies donate a certain amount...and that money is available to the dean to do what we want with... I don't think we'll see in I.T. a situation where money will be tied down to the specific needs of a particular company.

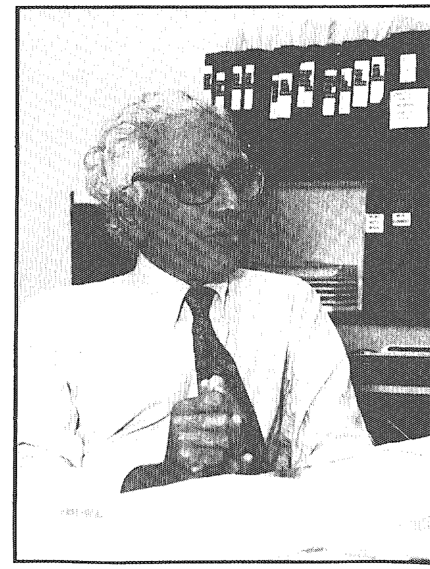


Technolog: Will I.T. be able to meet the demand for engineering manpower in the state?

Murthy: No. The state's needs for science and technology manpower are very immense, particularly in the so called high tech. areas. Unless funds from the legislature were doubled so we could build vastly larger departments we would not produce the numbers necessary. But there are other ways of producing the number of B.S. level graduates that industry wants. We are the only major graduate research institution in the state. We concentrate on advanced research. If our only mission was to produce four times as many engineers at the B.S. level, we wouldn't be a first rate University. The approach that we're now taking is to create engineering at outstate campuses and other colleges, along with possibly creating engineering programs within the private school system, such as at St. Thomas or Macalester. That would contribute to the steady manpower needed. But the function of the big university is not only producing manpower, but going beyond that.



Technolog: If a nearby college, say St. Thomas, were to get an engineering school, would the competition be beneficial to the University?



Murthy: I think competition is always beneficial... but the competition should be cooperative. Their work should be complimentary to ours. That is why we have a very close relationship and a lot of dialogue with out-state colleges that are introducing engineering programs.

Technolog: What effect will these new engineering programs at state colleges have on I.T.?

Murthy: That is difficult to determine because these programs are just starting.... What I think will happen is that science and engineering students who look at baccalaureate degrees as terminal degrees for employment will probably tend to go there just as well as they might go here. We take off from there and go onto higher levels, so students whose career plans include research or higher levels of technical management will route through here. That is what I mean by complimentary programs; we produce different kinds of people, both of whom are needed in the state.

Technolog: What is the status of the proposed Electrical Engineering/Computer Science building?

Murthy: We went to the 1983 legislature with our proposal and did

Continued on page 44

Peat from 11
refers to the production of energy or biomass crops, crops such as cattails, reed grass, alder, willow, or other wetland shrubs, to be produced directly on the undisturbed peatlands. These crops can be harvested annually or at other regular intervals, and the biomass may be processed for use as an energy source (via gasification, liquefaction, direct burning, or briquetting).

The obvious advantage of such an approach is its virtually unlimited expected lifetime, which means it is a long-term rather than short-term answer to Minnesota's energy woes. Energy crops might also be used to reclaim mined peatlands. The environmental impact of biomass production is largely unknown but is probably minimal. On the other hand, it appears that this approach could require as much as ten to 100 times the peatland area required by extractive processes to produce the same amount of energy.

How should peatland development proceed in Minnesota? The issue would be less controversial if we lived in an energy-independent state such as Utah or Alaska. Unfortunately, the energy future of Minnesota appears dim unless alternative energy supplies are found. The Minnesota Energy Agency (MEA) projects that by 1990 the demand for energy in Minnesota could overshoot the available supplies of traditional fossil fuels. Minnesota's peatlands, however, could provide up to 1.29 quads of energy, which is approximately equal to the total amount of energy used by Minnesotans in 1980. It is no wonder, then, that politicians and business people are looking to peat for a possible answer to the energy dilemma.

Though the development of Minnesota's peatlands may decrease our energy dependency, serious environmental, economic and social damage could result without proper research and planning by government and business leaders. Questions must still be raised and resolved before a complete and comprehensive plan for peatland development will emerge, before a reasonable peatland development effort can be mounted in Minnesota. Will the effort be cost- and energy-effective? What is the expected lifetime of the industry? Are there hidden social, economic, or environmental costs, or are there any previously unforeseen long-term effects of peatland development? Does small-scale harvesting of peat for local use make more sense than large-scale, centralized production of peat energy? What energy and economic alternatives are there to peatland development? It is clear that peatland development in Minnesota must be accompanied and guided by a well-conceived and carefully followed policy.

Policy options include nonrenewable resource extraction, renewable resource extraction (energy crops), and preservation. Policy makers must consider many variables, all complex and interrelated, to determine which of the three options, or combination of options, is best suited for Minnesota.

More than 90 percent of Minnesota's peatlands currently lie undisturbed. Though policy makers are not likely to opt for total preservation of these acres, many environmentalists, scientists and others have produced strong arguments for such a choice. Peatlands represent a unique ecosystem, one requiring thousands of years to form and reach maturity. Scientists recognize this rarity and the unique scientific value peatlands hold, especially in Minnesota. For example, the Big Bog Peatland lying in Koochiching, Lake of the Woods, and Beltrami counties occupies 450 square miles, making it the largest contiguous peatland in the lower 48 states. Peatlands may be Minnesota's last true wilderness.

While scientists and environmentalists argue for preservation for environmental reasons, many sportspersons and hunters support a preservation policy for recreational purposes. Yet because peatlands lie in remote areas, often hundreds of miles from population centers, their recreational value is generally limited to nearby residents. However, these same residents may oppose preservation, arguing that "urban environmentalists" seek wilderness preservation in distant rural areas that they have no right to govern. Rural residents claim that their right to jobs and economic development is overridden by city dwellers looking for weekend wilderness retreat areas. Since environmentalists are increasingly found in rural as well as urban locations, the preceeding argument lacks popular support.

To the dismay of some and to the applause of others, peatland development is likely and, in fact, is already occurring, though on a very small scale, near Virginia, St. Cloud, and St. Francis, Minnesota. According to Ron Visness, Department of Natural Resources (DNR) peat specialist, the only questions remaining concerning future peatland development in Minnesota are "how big and when."

To what extent shall peatland development occur, then, and shall we use Minnesota's peatlands for renewable resource extraction or nonrenewable resource extraction? The economic feasibility and social popularity of peatland development options are important and depend on many factors. The following considerations were suggested by the Center for Urban and Regional Affairs (CURA) in their 1980-81 study on peat, which culminated in the report *Energy from Peatlands: Options and Impacts:*

1. What are the quality and quantity of Minnesota's future energy demands?
2. What are the developmental costs?
3. Of the available options, how do their energy efficiencies compare?
4. Of the available options, how do the long- and short-term energy supply stabilities compare?
5. Of the available options, how do the economic, social, and environmental impacts compare?

An important concern when determining the feasibility of peatland development is the quality and quantity of future energy needs and whether these needs will be wholly or even partially met through peat development. Another concern is the consumer's ability to easily and economically convert and adopt the energy to his or her home needs, or on a larger scale, to industrial needs. As with all policy decisions, economics plays a major role. Profit margins must be competitive with existing energy production industries for companies to venture into peat production. The market value of peat must not exceed the price of traditional energy sources if consumers are to adopt it as an alternative energy source. All peat development projects currently underway in the United States and in Minnesota are heavily subsidized with federal funds, leading skeptics to question whether peat development will ever be economically feasible as a private venture.

Peat contains fewer Btu's per pound than any other known fuel source; hence its energy efficiency is low compared to traditional fuel supplies. If capital and research investments are diverted into peat production industries, the energy efficiency is likely to increase. However, one wonders whether government subsidies directed toward conservation policies and renewable energy resources might not yield an energy contribution equal to or beyond the energy obtainable from peat—a long-term energy solution.

Harvesting energy crops appears to be the most stable long-term solution to Minnesota's energy needs and will likely become the state's leading reclamation option. The DNR plans to replace the extracted peatlands with renewable energy crops almost on an acre per acre basis.

Another reclamation option for Minnesota might be forestry, the reclamation option chosen by Scandinavia. In Minnesota, as in Scandinavia, there is a large pulp and paper industry that could benefit from an increase in forest lands. In either case, a renewable energy industry will slowly replace nonrenewable peat extraction, making long-term economic stability far more likely.

Even if economic stability can be ensured, a final obstacle, perhaps the toughest, remains for policy makers deciding the future of peat development in Minnesota: of the foreseeable economic, environmental, and social impacts resulting, how will they be ranked in importance; which shall take precedent, which shall be sacrificed?

The economic, social and environmental impacts resulting from peat development will depend on the nature, scale and location of the peat projects selected. Like any energy industry, the impacts of peat development in Minnesota may be both beneficial and deleterious, possibly selectively benefiting (or harming) various members and groups of society.

Sweden parallels Minnesota in that Sweden's peatlands are also found in economically depressed areas. Mikko Valli of Rasjo Torv, Peat Consultants, Sweden, claims that "on 100,000 acres of peatland in Finland, we have created 3,500 jobs, straight on production; plus those making the equipment, delivering the peat, maintaining the facilities for industry, we are talking about 8-10,000 people working in the industry. And that's in development over a ten-year period."

Minnesota's economically depressed Iron Range, crippled by skyrocketing unemployment, urgently needs an economic booster like peat development to cure its economic woes. The local people recognize this and generally support peatland development. If a project were carefully tailored to the northern region's needs in a decentralized manner, economic benefits might outweigh the social and environmental costs.

Whether or not sufficient lead time is created between the planning and construction phases of a peat project might affect the extent and quality of an employment training program for local workers. If little or no training is provided, imported labor would have to be used, and local residents might be left worse off than before. Imported laborers and their families might create an excessive strain on public services, and possibly cause a housing shortage, especially in rental units. Though peat can only be mined during the months of June through September, when unfrozen lands lie open for harvesting, Valli claims that the jobs involved are not seasonal. "When we talk about jobs, they are year-round. We don't harvest peat in winter, but we deliver it and we do the service and prepare new fields [for production]. [The workers] are not laid-off."

While seasonal unemployment may not be a problem, the need for government subsidies, synfuel money, leads some to argue that Minnesota's peatland development plans merely provide a temporary fix for a region whose economic demise has already come. The argument goes that patchwork economics only forestalls the eventual economic crisis, and often creates additional problems associated with a boom-bust economy. The reclamation plans to grow energy crops counters this argument, however.

Still, there are many environmental impacts to consider. Because peat is surficially mined, the land faces a variety of impacts, affecting all aspects of the ecosystem. Impingement upon wildlife lands is of utmost concern to environmentalists, as are the problems and results of reclamation. Air quality may suffer too, as fugitive dust, small soil particles and peat fibers emitted during extraction and handling of peat get carried downwind, sometimes up to twenty or even thirty miles. These effects can be minimized, though, by covering storage piles, using water sprays, windbreaks, or a combination of all of these methods. Fossil fuel emissions from heavy machinery used in the construction and operational phases of a peat industry could harm the small, localized, fragile ecosystems surrounding the project as well.

Water, vital to the ecosystem, may be directly affected by peat mining, too. For example, both milled and sod peat mining require extensive draining of peatlands prior to extraction. Drainage will undoubtedly affect groundwater levels and flow patterns of underlying and adjacent aquifers, which in turn may affect surface waters. Limnological and groundwater studies are still needed to discover the complex hydrological systems associated with peatlands. Peat is also thought to absorb heavy minerals, mercury (Hg) and zinc (Zn) to name a few, which might be released into the surrounding ecosystem via discharge waters. Questions remain to be answered.

Here in Minnesota the DNR has divided our state owned peatlands into three categories of future use: 0.5 million acres are to be set aside for preservation, 2.5 million acres will be reserved for future generations, and 1.1 million acres are reserved for development. The proposed peatland development areas are found in northeast Aitkin County, southwest St. Louis County, and parts of Carleton County.

The state has studied peatland development since 1976, the year Minnegasco first took an interest in using peat for large-scale gasification. Though the Minnegasco project proved economically unfeasible, and the company has since lost interest, the state and especially workers at the DNR have acquired considerable knowledge about peat and its uses. For this reason the DNR has chosen state-owned peatlands over privately owned peatlands for the initial peat development phase, ensuring cooperation between the state and private developers, like Rosjo Torv.

On August 17, 1983 Rosjo Torv was granted a preliminary lease on 2,600 acres of peatlands. This trial peatland development area is located near Zim, Minnesota, a small town about 45 miles northwest of Duluth. Of the 2,600 acres, approximately 150 acres will be harvested there and tested in existing boilers beginning in fall 1984. Sod peat was chosen over milled peat because of its greater handling and transportation ease, higher energy content, lower dust levels, and potential economic feasibility.

According to Valli, "The first thing is we have to find out the feasibility . . . whether we can make money, *live* with it. We think it is feasible according to the market studies we've made, according to the preliminary data . . . . One and one-half years from now we'll know if it's feasible. After that we go to industrial scale. Then it's up to the market, how fast the market grows."

The tension and anxiety once surrounding peatland development have largely subsided since the land most sought after by developers is not the same land environmentalists seek to protect. A compromise has probably been reached. Says Visness, "Nobody is being forced to make an all or nothing decision. Development has been focused into a few areas. Within these areas we have all kinds of peat to focus on any type of development option they desire."

Minnesota's legislators made a significant step this year to help ensure careful peatland development and reclamation by passing the state Mining and Reclamation Act. Even if reclamation is guaranteed, however, the peatlands targeted for development will forever be lost. The energy and jobs peat industries create will certainly be welcome, but even Visness, one of our state's leading peat experts, has no illusions of ever attaining energy independence: "We're not going to be an energy-independent state any more than this country is going to be an energy-independent nation." ■

Mary Wilkosz is a senior majoring in geology, and **Jim Lundy** is a geology graduate student.

TechnoFlog

By Stephen MacLennan
Al Hauser

"If the Dean doesn't take back what he said to me this morning, I am going to leave college!"
"What did he say?"
"He told me to leave college."

ME: "I like mathematics when it isn't over my head."

EE: "I feel the same way about pigeons."

Math student: "Was it very crowded at the pub last night?"

Physics student: "Not under my table."

Chem Prof: "This fluid turns blue if your unknown is basic and red if the unknown is acidic."

Student: "Sorry, but I'm color blind. Got anything with a bell on it?"

Overheard in EE lab:

First student: "Roy, grab this lead. Feel anything?"

Second student: "No."

First student: "Then watch out for the other one; it's carrying 22,000 volts."

Mathematics is Like a Pigeon

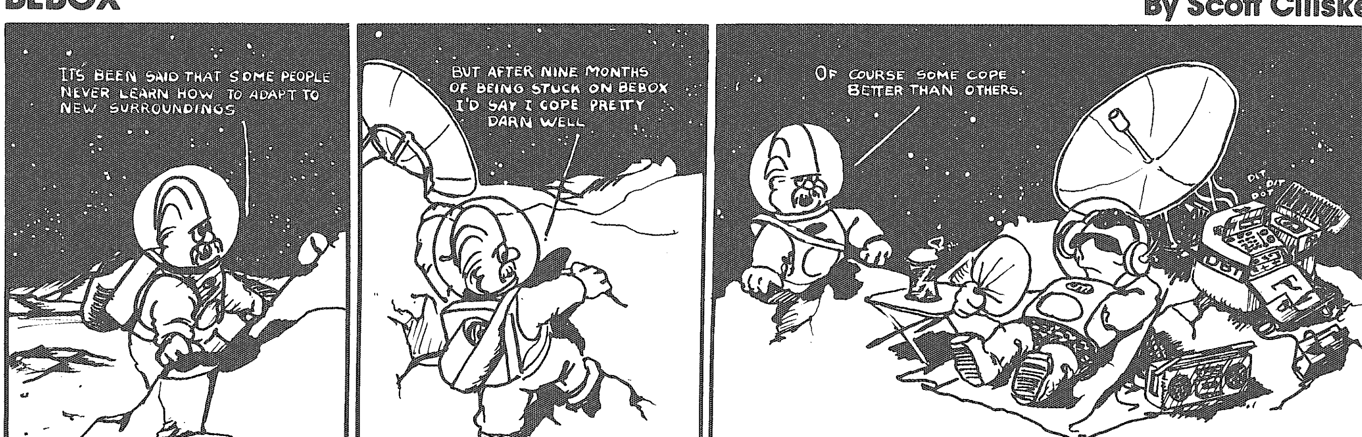
One day Leif and Woody, two forestry students, decided to go fishing. Upon arriving at the lake they rented a boat and rowed to the middle of the lake. To their surprise they started catching one fish after another. In a couple of hours they had more than what they could use and were ready to quit.

"Leif, this is sure a great spot! How can we mark it?" Woody said.
"I know," said Leif. "We can put an 'X' on the bottom of the boat!"
Woody laughed and laughed and laughed.
"What a stupid idea!" he said. "How do we know we'll get the same boat next time?"

Brain Teasers

1. There once existed a very strange university. At this university every freshman, being naive, always tells the truth when asked a question. Every junior, due to the pressures of heavy coursework, always lies. Every sophomore, caught halfway between freshman optimism and junior despair, alternately lies and tells the truth, but there is no means of knowing whether a sophomore's answer to the first question he is asked is a lie or the truth.
   One day a very bright senior and her freshman roommate encountered a group of three students named Frank, Susan, and

BEBOX **By Scott Ciliske**



Jerry. The freshman roommate informed the senior that the group consisted of a freshman, a sophomore, and a junior, but she did not know who was who.

"No problem," said the senior. "Susan, are you a freshman, sophomore, or junior?"

"I am a sophomore," replied Susan.

"And Frank?"

"He is a freshman."

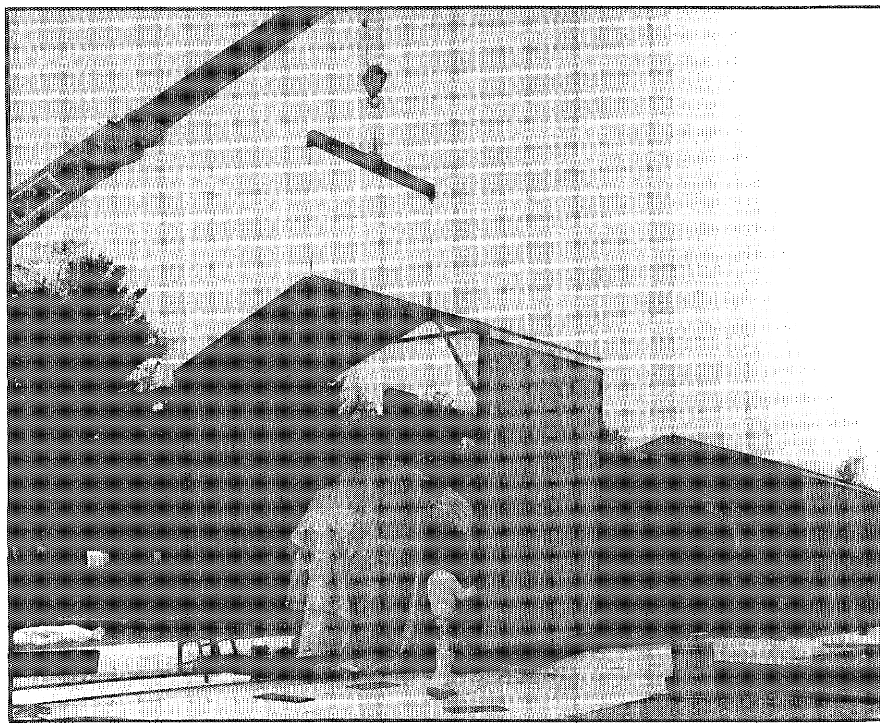
"So Jerry is a junior?"

"Of course."

Who is who?

2. Can you arrange the digits 1-9 on a triangle, one at each corner and two on each side, so that the sum of their squares along any line is the same?

Brain teaser solutions on page 44



Work on Iowa's first nuclear-powered submarine was halted last month when it was discovered that the state was landlocked and had no lakes. The vessel is now being used as a milk tank on Fred Peterson's dairy farm.

Technotrivia ???

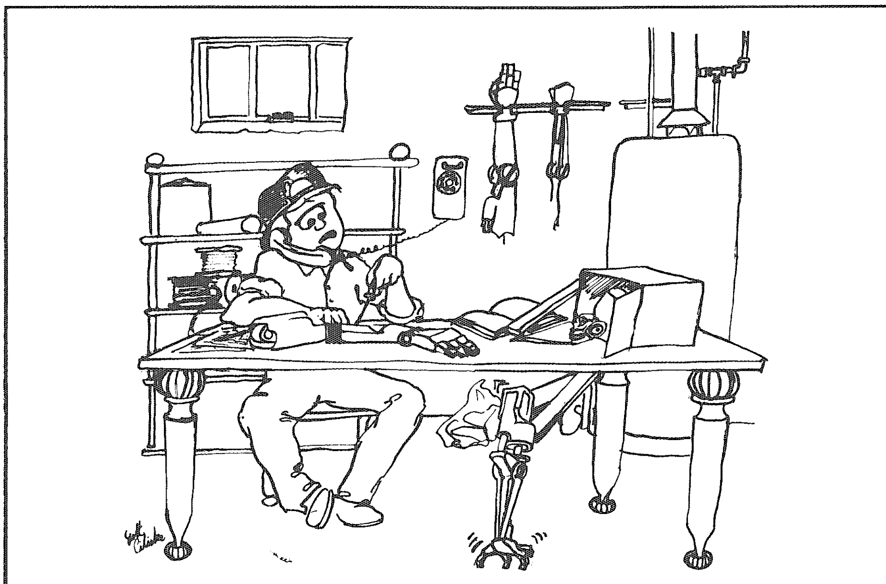
By L. Phillip Gravel III

1. On December 17, 1903, history was made at Kitty Hawk, North Carolina. This was the day that two sons of a preacher, Orville and Wilbur Wright, became the first men to fly. Actually there were two flights that day. The first flight was for 120 feet and the second for a booming 852 feet. The question is, which of the two Wright brothers flew that first 120 foot flight? You have a 50-50 chance here so subtract one point from your score if you guess incorrectly.

2. According to a 1978 United Nations survey, what place on earth consumes the most energy per capita per year? What country consumes the least?

3. This substance was first manufactured commercially in 1925 by Prest-Air Devices Co. of Long Island City, New York. It is made by compressing and cooling a chemical compound to -109° F. In this process the compound changes from gas to liquid to solid. What is this substance, and from what compound is it made?

4. No doubt you've walked across the Washington Avenue bridge for one reason or another. Under it flows the Mississippi River, which begins at Lake Itasca and heads south, picking up fluid from tributaries and waste disposal plants along the way. The question is, what is the average flow rate of the Mississippi River as it passes through the Twin Cities and hence under the Washington Avenue bridge?



"YEAH, AND THEN WHEN I BUILD ENOUGH I'M GOING TO RACE 'EM."

5. According to a 1978 U.S. Department of Health, Education, and Welfare study, which occupation is least stressful: an auctioneer/huckster or a university professor?

Which Wright is Right?

6. In World War II the Allied forces considered building an aircraft carrier 2,000 feet long by 300 feet wide, weighing an estimated two million tons. Although a 1,000 ton prototype, built in Canada in 1943, performed remarkably well in tests, the real ship was never built because of its strange hull material. What was this material which made people so skeptical?

7. In the 1963 book *Planet of the Apes,* journalist Ulysse Merou, scientist P. Antelle, and physician Arthur Levain discover the second planet of the giant red star Betelgeuse. The planet has the same characteristics as Earth except for one big difference: on this planet the apes rule and humans are mere beasts. Name this planet and the year the three humans discovered it.

Trivia answers on page 44

L. Phillip Gravel is a senior civil engineering student. He told us he wanted his picture and phone number printed here, but we told him it was against *Technolog* policy. (Maybe next issue, Phil.)

Technotrivia Answers

1. Orville Wright made the first flight. Source: Wallechinsky and Wallace, *The Peoples Almanac #3,* New York, William Morrow and Company Inc., 1983.

2. Most: U.S. Virgin Islands, 542,830 kilowatt-hours per person per year. Least: Nepal, 110 kilowatt-hours per person per year. Thus the average person on the Virgin Islands uses as much energy in one day as a person in Nepal uses in 13.5 years! The U.S. is the eleventh largest per capita user, using an estimated 115,555 kilowatt hours per person per year. Source: *World Energy Supplies, Statistical Papers Series J,* New York, United Nations, 1978.

3. The substance is dry ice. It is made from carbon dioxide. Source: Joseph Kane, *Famous First Facts,* New York, H.C. Wilson Co., 1981.

4. The maximum flow rate of the Mississippi at Minneapolis in the past five years was 91,000 cubic feet per second on April 17, 1965. The minimum flow rate occurred August 29, 1976, at 529 cubic feet per second. The average flow rate passing through the Twin Cities is 7,558 cubic feet per second. For you people from Wisconsin, that's approximately equal to 3,529.2 kegs per second. Source: *Water Resources Data For Minnesota,* U.S. Geological Survey in cooperation with the Minnesota Department of Natural Resources, 1980.

5. In listing the least stressful occupations, a college or university professor finished eleventh while an auctioneer/huckster was thirteenth. Source: *Occupational Stress,* U.S. Department of Health, Education, and Welfare, National Institute For Occupational Safety and Health, 1978.

6. The material was called "pykrete." Pykrete was invented by a British man named Geoffrey Pyke and was simply a mixture of ice and sawdust that did not melt easily. Source: *Significa,* New York, E.P. Dutton Inc., 1983.

7. The name of the planet is Soror, which means "sister" in Latin. It was discovered in the year 2,500. Source: Pierre Boulle, *Planet of the Apes,* 1963.

Score

0-1 Forestry students aren't supposed to read *Technolog.*

2-3 Not too bad!

4-5 Definitely a regular *Technolog* reader.

6-7 Which galaxy are you from, anyway?

Brain Teaser Solutions

1. Susan is not a freshman, for if she were, she would say so. Susan is not a sophomore, for if she were, her first answer is truthful and hence her third answer must also be truthful. If this were so, the second answer would be truthful too, but this is impossible, since sophomores alternately lie and tell the truth. So Susan is a junior. All her answers are lies. Frank is the sophomore and Jerry is the freshman.

2. One solution is a triangle with 5,9,4,2 on one side, 2,3,7,8 on another and 8,6,1,5 on the third.

Ad Astra from 34

since Marxism was conceived at a time when classical physics was influential, while existentialists draw support from early modern physics.

The point that ends up being made, however unintentionally, is that scientific reasoning is not always applicable to human value judgments. You can have a lot of fun playing with logical puzzles, but on the level of political and philosophical maneuvering, the crystalline abstractions of mathematics may have little to do with the laws of the game.

Murthy from 37

not get anything.... The building was not our highest priority last year. But an initiative came from the Minnesota High Technology Council and the governor. They said that the state immediately needs this building. We ought to be a first rate University in the Computer Science and Electrical Engineering departments and we cannot afford to wait. So in order to expedite the process, the governor offered some money he had, provided the University and the High Technology Council could match some of these funds. The governor offered $960,000, and the University was to come up with $320,000 and the Council $320,000.... The idea was to start planning immediately, and while we were doing this go to the 1984 legislature for either the rest of the planning money ($3.6 million total is needed) or the rest of the planning money and some construction money.... Then just as this plan was to be implemented [during early October] some friendly advice came to the governor from legislative leaders. They thought this plan might backfire, that it could be seen as a pressure tactic.... So legislators friendly to the University felt that we should wait another six months. The advice has been taken. The present plan is to go to the 1984 legislature with a request for the total planning money, then follow through in 1985 with the construction.

Dean Murthy concluded by saying that I.T.'s goal within the next four years is to establish two or three more "nationally prominent" departments. By that he means in the best 8 to 10 nationally. The Aerospace and Mechanics, Chemical and Mechanical engineering departments already meet this criterion and Murthy targets electrical engineering and computer science for future national prominence. Dean Murthy invited *Technolog* back for a followup interview, so if you have any questions, please let us know. ■

Mike Sorenson is a senior math major. This story would not have been possible without his keen and perceptive questions (not to mention his tape recorder.)

Technopuzzle

By Mark "Dr. Death" Stolzenburg
Dan "the Dictionary" Rader
Dandy Randy Smith-Kent
Al "the Alphabet" Hauser

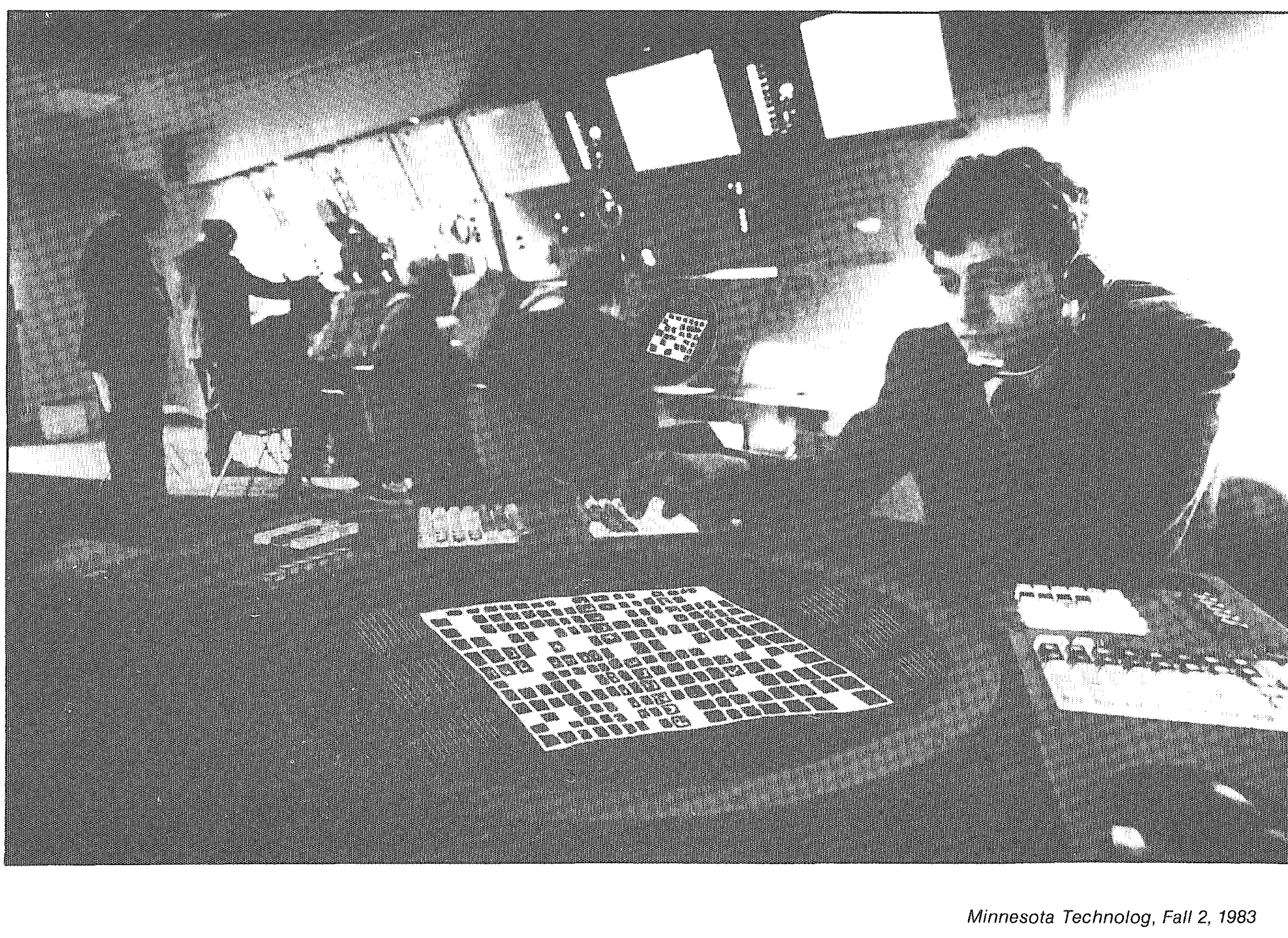
Welcome to another Technopuzzle! Once again be prepared to stretch your vocabulary to its absolute limits! Rumors that many readers found last issue's puzzle too easy have floated into our office, so Dr. Death and company have put together an extra challenging set of clues. In keeping with this issue's theme, many of the words are related to energy.

Last issue's big winner was Doug Brown, a senior in electrical engineering. Doug led the charge to the *Technolog* office and, for his efforts, was awarded a fabulous "Do I.T. with an Engineer" T-shirt. A similar treasure awaits the first genius to enter Room 2, Mechanical Engineering, with the correct solution to this issue's Technopuzzle.

Good luck! (Dr. Death says you will need it.)

Fall 1 Technopuzzle solution

1 D	2 I	F	3 F	E	4 R	E	5 N	6 T	7 I	8 A	9 T	10 I	11 O	N
12 E	E		L		A		13 V	O	L	T	A	G	E	
		14 Q	U	A	R	15 K		T						16 D
17 F	L	U	X		18 E	I	19 G	E	20 N	21 V	22 A	L	U	E
U		A		23 A		24 N	I	M	B	U	S			G
25 E	26 I	N	27 S	T	28 E	I	N		A		29 H	O	U	R
30 L	A	T	E	N	T						R			E
C		U		31 O	H	32 I	O		33 O	34 P	A	Q	U	E
E		35 M	36 A	S	E	R		37 P	O	L	E			R
L			N		38 R	O	T	A	T	E			39 P	A
40 L	41 U	42 M	E	N		N			43 W	A	44 R	45 R	E	N
	46 M	E	R		47 I		48 T			49 S	P	A	R	K
50 A	B	S	O	51 L	U	52 T	E			A		53 T	I	I
54 D	R	O	I	D		55 E	X	56 P	57 A	N	58 S	I	O	N
59 C	A	N	D	E	L	A		60 C	A	T	H	O	D	E



Across

1. Heat-absorbing

10. Degree not found on thermometer

12. Nuclear advocates think Jane Fonda is ______.

13. Major fossil fuel consumer

14. Vegetable fuel

16. 1.341 x 10^{-10} HP-sec

17. Leader (abbr.)

19. Point of applied power on two-wheeled vehicle

21. State where Trident submarines are made (abbr.)

22. North American Air Defense Command (abbr.)

24. Alkene of formula weight 126.24

26. One __________ law precludes perpetual motion machines.

27. With regard to (abbr.)

28. Industrial Engineers of Iowa (abbr.)

29. "______ of the Apostles."

30. Condition of taconite miner at day's end

33. Antecedents include "sci" and "hi"

34. A likely precursor of a British space program

36. Feet of _____

37. Height above sea level (abbr.)

38. Institute which establishes safety codes (abbr.)

40. Direct crossword complaints to the guys in the ____-line.

41. -(A.D.)

42. Reactor fuel (abbr.)

43. Temperature measuring device (abbr.)

44. Solar devices utilizing 65 across

48. Lightest unnatural element (abbr.)

50. Path of 15 down

51. Room temperature (abbr.)

52. Mono + di = _____

53. The small, white variety are often considered harmless

54. Alcohol refinery

55. Discipline studying 15 down (abbr.)

60. Temperature measuring device (abbr.)

62. When this goes up, it never comes down

64. Roughly 3.1416 x 10^7 seconds

65. Most electropositive element (abbr.)

66. Ten (prefix) (abbr.)

67. Moon of Jupiter

Down

1. Hand-held power source (two words)

2. Likely to raise heating bills

3. Followed E.T. when drunk

4. In a power-consuming state

5. Pertaining to a basic structural unit of the vascular plant

6. Potable-powered

7. Electric time constant

8. Gasoline-saving device

9. Large container for many to observe energy-dissipating events

10. Atomic number 56 (abbr.)

11. Energy intensive industry

14. Emotional condition during LOCA

15. Current forms of energy

18. Fuel-saving type of tire

20. Set on which a function is defined

22. Nuclear reactor (abbr.)

23. Vector product

25. Likely sponsor of far-out energy project (abbr.)

31. Oblique angle (abbr.)

32. State home of Brookhaven National Labs (abbr.)

33. Poor choice for nuclear power plant site

35. Characteristic of A-bomb material

39. "There's no more power, Captain!" (two words)

41. Key component in steam-generation system

42. Hawaiian food

45. General class of fuel (abbr.)

46. Reservoir of tidal energy

47. Measure of sound recording power often used on tape deck analog meters (abbr.)

49. Fourth largest Mediterranean island

54. "Request-to-______"

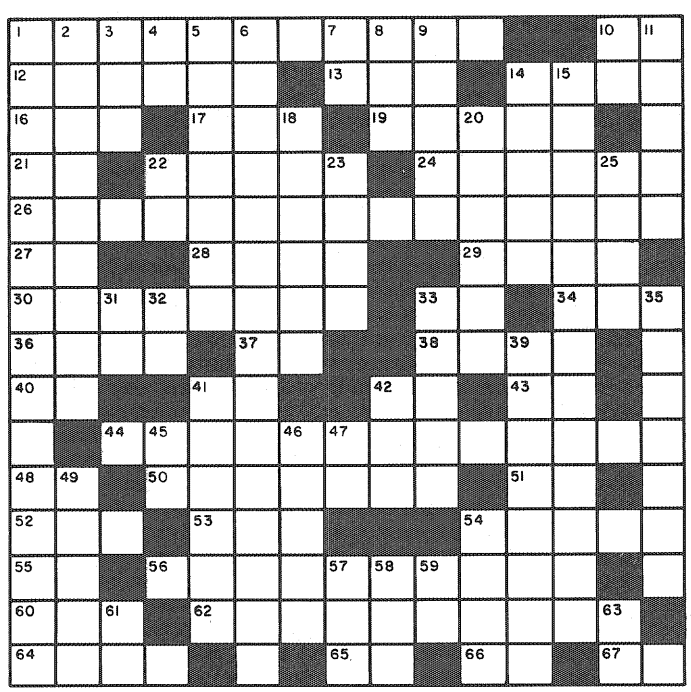
57. Analog/digital converter (abbr.)

58. Type of FET (abbr.)

59. Post meridiem (abbr.)

61. Digital to analog (abbr.)

63. MKS (abbr.)



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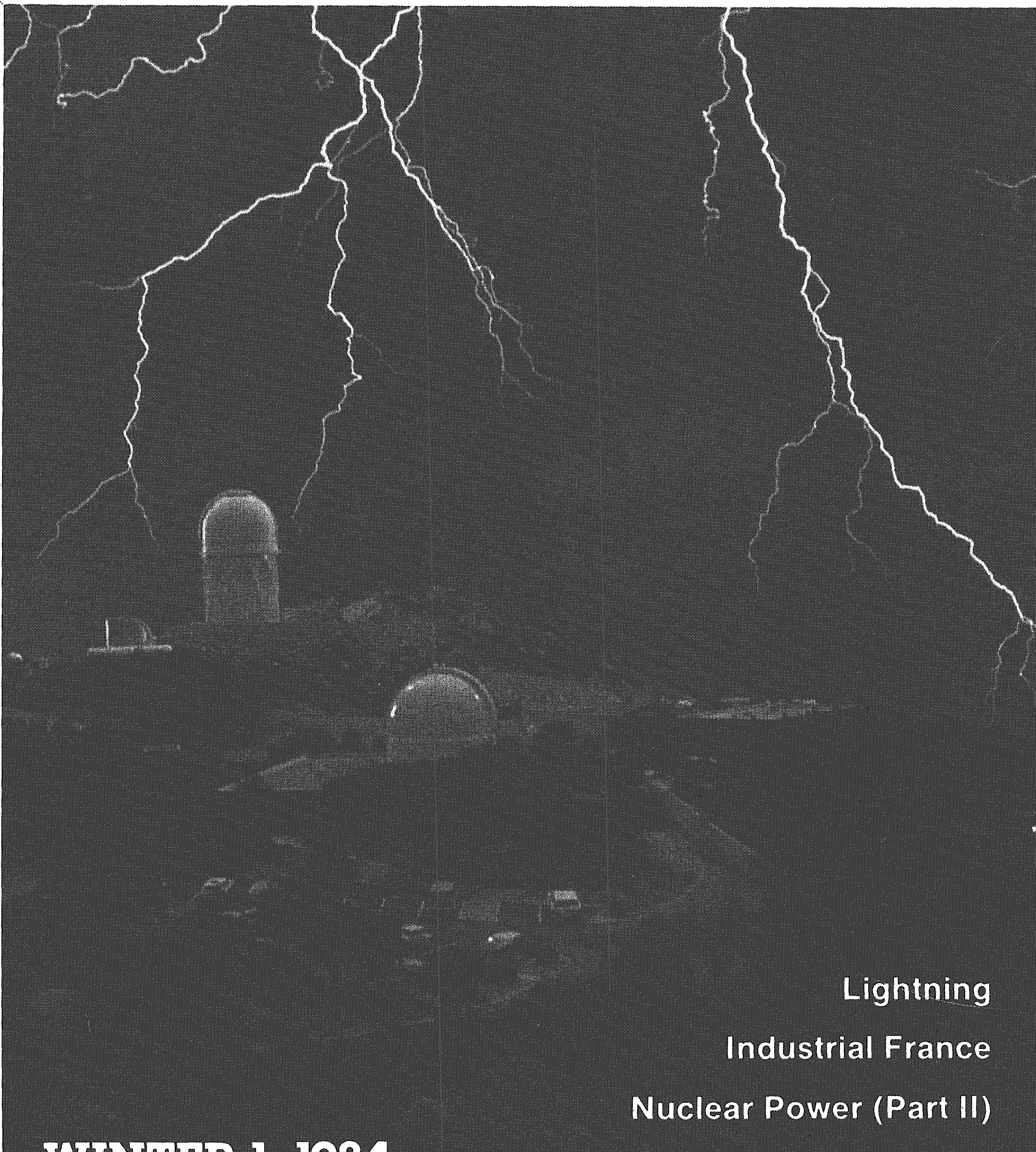

Lightning

Industrial France

Nuclear Power (Part II)

WINTER 1, 1984

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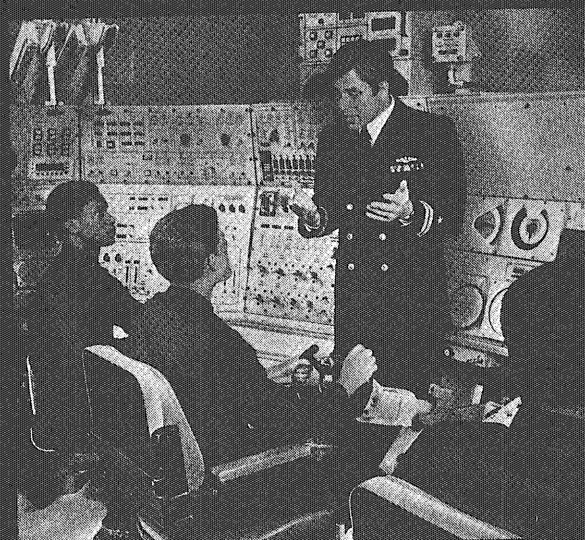

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ECM 2/84

Navy Officers Get Responsibility Fast.

Winter 1, 1984

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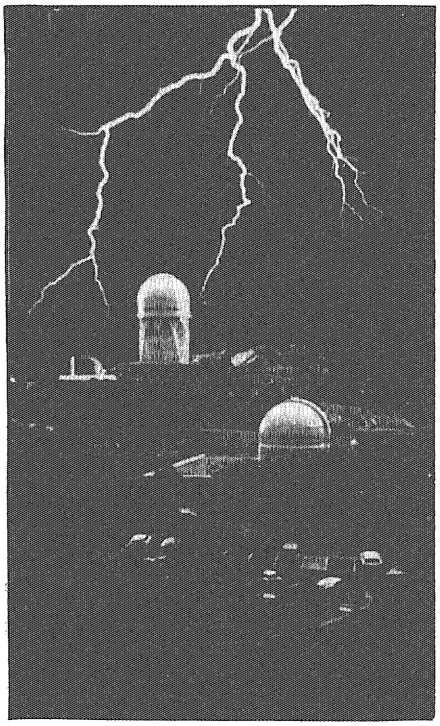

Lightning frames the four-meter Mayall Telescope, largest on Kitt Peak National Observatory. The one-minute exposure was taken by Gary Ladd during a June 1972 thunderstorm.

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Karen Lovass
Matt Pedersen

Faculty advisor
Dr. John N. Clausen

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Editor's Log

A Global View

"Stimulating," "enlightening," "exciting," "a real learning experience." No, these I.T. students were not talking about a 5000-level math course or even a textbook on material processing. Each student had studied or traveled abroad and was merely describing his or her experience. Although many had not attended foreign universities, all felt that the time spent overseas was a valuable addition to their education and that they had discovered things which could not be found in a textbook.

Opinions vary, but most students agree that the most rewarding part of their trip was the chance to "experience other cultures." In fact, this phrase is heard so often when talking about foreign travel that it has become a cliche which holds little meaning for most people. It is actually a three-word package which stands for exposure to different lifestyles, different ways of handling problems, and different values. The overseas traveler finds himself thrown amongst political, educational, judicial, and social systems unlike those with which he has interacted since his birth. A visitor to Spain will have a difficult time finding a souvenir or snack between 2:00 and 4:00 p.m. because all Spanish stores close for siesta, an afternoon break. Imagine living in a country where the leading party rarely attracts more than 40 percent of the vote. Such is the situation in France, where a socialist government is now in power. The movie "Midnight Express" vividly portrays a judicial system which is vastly different from America's. A tourist in London will find policemen who do not carry guns—and a lower violent crime rate. Policies concerning alcohol, care for the elderly, and social welfare in other countries deviate significantly from ours, as do the results of these policies. In the worst case an American abroad obtains a new tolerance for different cultures, and in the best case he will be forced to reexamine homegrown ideas, appreciating some but seeing the faults in others.

An excursion abroad not only teaches a student many things about countries and cultures; a surprising amount is learned about one's own country. American foreign policy can become tainted when seen through the eyes of an African or Arab. American materialism is condemned and not condoned.

Also mentioned by I.T. students who have been abroad is that their travels have increased their self-confidence and their level of independence. Anyone who enters a foreign town without food or currency and discovers that his traveler's checks are still on a train bound for the next country understands what is meant by this. A student thousands of miles from the United States has only himself or herself to turn to when unexpected incidents occur. The end result is a more confident, independent person.

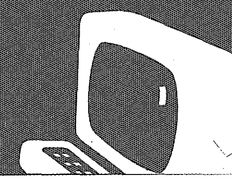
The advantages of traveling abroad are many, and with the dollar making a strong showing on foreign markets, travel in 1984 will not be as expensive as it once was. Keep your eyes open for a good deal and check with the International Study and Travel Center in Coffman Union for information on some of their excellent programs. Overseas travel usually does not fit well into an engineer's or scientist's academic program, but most students who have gone abroad feel that they have learned more from the experience than any of their classes.

Alan Hauser

Alan Hauser

Editor

Log Ledger



I.T.'s Bulletin Board

By Scott Dacko

- **Association for Creative Engineering Formed**

The Association for Creative Engineering (ACE) is a new student organization in I.T. that was formed for the purpose of promoting invention, innovation and entrepreneurship. Each year ACE will sponsor an Innovation Fair, a competition for I.T. students to create marketable products, and in addition will provide many support activities, such as business seminars and working facilities, to inventive engineering students. Rules and information about the Innovation Fair can be obtained by stopping by or writing to The Association for Creative Engineering, 265 Experimental Engineering, University of Minnesota, Minneapolis, MN 55455. Or call Scott Dacko, coordinator, at (612) 331-8077.

- **Engineering Internships Available**

The International Study and Travel Center (ISTC), located in Coffman Union, advises students on the various internship programs and positions available overseas. The services of ISTC are free of charge, and students can walk in any time, though the advisors strongly encourage appointments.

Engineering internships, less numerous than other internships, are available to a small degree from organizations such as the Peace Corps, the United Nations and some foreign governments, such as Australia. The majority are available through an organization called the International Association for the Exchange of Students for Technical Experience (IAESTE). Open to all undergraduate students in the sciences, engineering, mathematics, architecture and agriculture, positions are available in 46 countries and range from eight weeks in length up to a year. A nonrefundable $50 application/membership fee is required, and if you are accepted and interested in a position, it is up to you to make the necessary passport, visa, insurance and travel arrangements. You will be paid a "maintenance allowance" to cover your living expenses while in such a training position.

If you are interested in an engineering internship abroad, make an appointment with an ISTC advisor. By Douglas Giles

- **Assoc. Dean Stueben Leaving**

Edwin Stueben, Associate I.T. Dean for Student Affairs, will be leaving the Institute of Technology to accept a vice president position at the University of Illinois. He will be leaving this December. We value the contributions he has made in I.T. and wish him the best of happiness in his new career.

- **In Remembrance of Dr. Whitby**

Ken Whitby, professor in the Mechanical Engineering Department, passed away November 14 at the University Variety Club Heart Hospital. He died of a heart attack. Dr. Whitby contributed much to the University during his lifetime. He is the man responsible for the formation of the Particle Technology Laboratory in the Mechanical Engineering Department. He performed research in many areas related to environmental engineering and particle technology, and he sat on numerous committees, both in the department and on a national level, with the purpose of improving the quality of life and our surroundings. We will miss him very, very much.

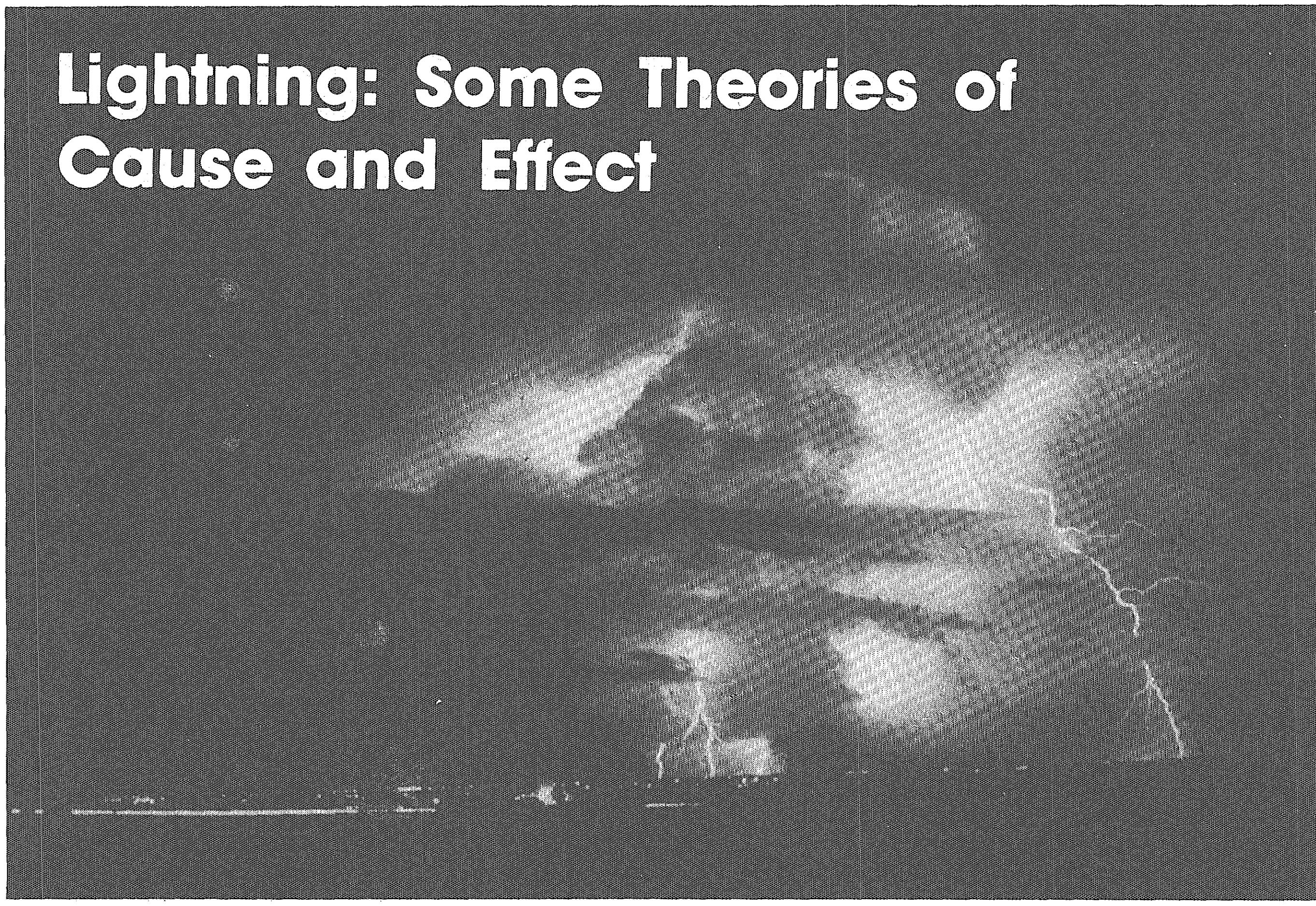
- **Automated Transportation Systems Inc.**

Automated Transportation Systems Inc. has been formed to establish, manufacture, construct and market a newly developed, high-technology personal rapid transit system (PRT) for use by the general public. The PRT system has been developed here in the Institute of Technology according to the design and direction of Prof. J. Edward Anderson of the Mechanical Engineering Department. Officers include Anderson, John C. McNulty, and Richard L. Gehring. Address: 557 Summit Ave., St. Paul, MN 55104.

- **Tau Beta Pi Convention Held**

Members of the Minnesota Alpha Chapter of the Tau Beta Pi Association at the U attended the 1983 national Tau Beta Pi convention held Oct. 6-8 in Urbana-Champaign, Illinois. ■

Lightning: Some Theories of Cause and Effect



By Jeremy D. Lanctot

Lightning has an integral effect on our lives. In the United States alone each year, it is responsible for the deaths of over one hundred people, causes millions of dollars worth of damage to buildings, and millions of dollars in damage to forests. In modern thought lightning is as much a symbol of power and destruction as it was in ancient times. Yet, because of recent research and meteorological advances, it is not the menacing threat it once was. This is an overview of some of that research and its practical applications, as detailed in interviews with two of Minnesota's leading researchers. But let us first take a look at ancient attitudes and beliefs towards lightning and the thunder that accompanies it.

Throughout history lightning was regarded as originating from the gods of the pagans and the God of Judeo/Christian tradition. According to the early Greeks, lightning was the weapon of the father god, Zeus. Zeus' favorite bird, the eagle, bore his thunderbolts, which were forged by the lame ironsmith, Vulcan. Even today, one can see the eagle clutching lightning arrows in his claws on the back of dollar bills. Roman mythology credits the invention of lightning to Minerva, the goddess of wisdom. There are 28 references in the Bible to lightning and thunderbolts. In Zechariah 9:14 it states, "And the Lord shall be seen over them, and His arrow shall go forth as the lightning," while in Psalms 78:48 it states, "He gave up their cattle also to the hail and their flocks to the thunderbolts." All the ancient traditions saw lightning as the weapon of wrathful divinities, while thunder was their shouts of anger.

It wasn't until 60 B.C. that the Roman poet-philosopher Lucretius tried by scientific reasoning to explain this powerful natural phenomenon. In *De Rerum Natura,* he held that lightning was in the "... cavernous clouds [that] hold seeds innumerable of fiery exhaltations." When describing the nature of lightning he wrote, "It goes through many things and leaves them whole, because the liquid fire flieth along through their pores." Descartes, the eighteenth century French philosopher, reasoned that thunderstorms were the result of upper clouds falling on lower clouds.

In 1749, lightning was first clearly identified as being electrical in nature. Benjamin Franklin's experiments in Philadelphia, along with those of T.F. d'Ailbart in Paris and G.W. Richmann of St. Petersburg (now Leningrad), are some of the best known for their discovery of the electrical characteristics of thunderstorms. This initial research was not without its dangers. Richmann was killed while trying to repeat one of Franklin's experiments.

In the early twentieth century, C.T.R. Wilson of Cambridge proposed the now generally accepted theory of the role of lightning as a balancing of the world of electrical charge. He proposed that lightning strokes continually return to the earth the negative charge which is lost by transfer to the upper atmosphere through conditions in the weakly ionized air.

In 1947, Morris Newman, a professor of electrical engineering at the University of Minnesota, founded the Lightning and Transients Research Institute. Presently this is the only nonprofit, independent lightning research facility in the United States. The institute is located next to the University of Minnesota's computer center in Lauderdale (with a branch in Tampa, Florida). It is a center of research concerned with the problems of computers and aircraft navigational equipment due to lightning-induced electrical transients.

Today the institute is under the direction of John Robb, whose disciplines are physics and electrical engineering. Although Robb believes "... there are as many different opinions on how lightning forms as there are people who research it," he describes what he believes to be the chain of events that lead up to lightning.

"[There is a] build-up of charge in the lower clouds, as hail forms in the updraft. When the hailstones reach a large enough weight, they fall again and slowly melt as they return to warmer air. The water stripped off by the combination of falling and updraft creates a potential difference. This continuous process causes a positive charge on the ground 80 percent of the time and a negative charge in the lower cloud cover. When the potential becomes great enough, it discharges in the form of lightning."

The lightning stroke is composed of a stepped leader which is guided initially by a pilot leader. (See figure 1.) The average lengths of these steps range from 10 to 80 meters. The pilot leader is a weakly ionized electrical discharge that advances from the cloud at the constant velocity of approximately $2x10^5$ meters per second. The average velocity of a step as it catches up to the pilot leader is approximately 10^7 meters per second or about 100 times faster than the advancement of the leader.

"The upper, or main, lightning stroke travels down to about 300 feet altitude level," Robb continues. "At this level streamers from the ground rise up to meet the main stroke. The charge is discharged through one of these streamers and delivered to the ground."

Most people who are struck by lightning are the source of one of these streamers which deliver a current of only about 50 amperes. This is enough to stop a person's breathing and/or heart. Sometimes, a person will survive a "zap" of lightning, but this is rare.

"When the current is discharged completely from the main stroke, a wave of ionization travels back up the stroke path to the cloud, known as the return stroke," Robb contends, adding, "This process may repeat itself many times rapidly in a second."

The velocity of this return wave of ions is approximately $4x10^7$ to $1.4x10^8$ meters per second or about half the speed of light. The current that travels through the lightning stroke averages about 20,000 amperes in the first 5 microseconds. Extreme values of current produced by lightning reach several hundred thousand amperes.

The average time between re-strokes is approximately 30 to 40 milliseconds. Before a re-stroke can take place, the old channel must be boosted by a dart leader (i.e. the re-stroke's pilot leader). The whole cycle, including initial strokes and re-strokes, is called a flash. Flashes contain about 3 to 4 strokes on average, but there have been cases where up to 48 strokes have been observed in a single flash.

Robb is presently doing consulting work for NASA's space shuttle program. He recently researched the question, "Will lightning produced by the exhaust of a rocket puncture the cooling conduit that surrounds the engine nozzle?"

If a lightning stroke were to puncture any part of this thin conduit, the liquid nitrogen would escape leaving nothing to cool the engine and nozzle. This would cause the engine to overheat and explode. One can see that the necessity of solving problems such as these cannot be overrated as the life of the crew and the success of the mission are at stake. However after calculating the speed at which lightning strikes and comparing it with the speed of the exhaust, it was found that the lightning wouldn't have enough time in contact with the engine nozzle to do any appreciable damage.

Professor George Freier of the University of Minnesota's Physics Department has a similar area of research. His specialization is atmospheric electricity. He and a colleague, Professor Don Olson of the University of Minnesota-Duluth, study the ways in which lightning damages computer networks and how to build circuitry that is immune to such electromagnetic interference.

He tells of a time during the Apollo 12 space mission when the spacecraft was struck twice by lightning during its flight through the atmosphere after lift-off. The only real damage done to the spacecraft itself was that some of the external sensors were rendered

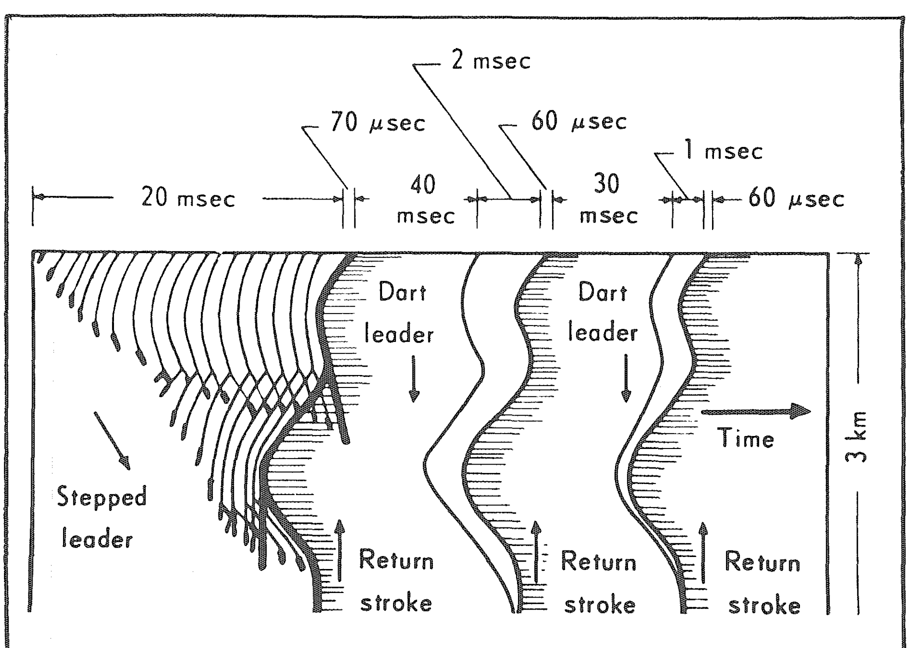


Figure 1

An artist's rendition of a fireball.

nonfunctional. However the computers were programmed to restart a calculation if 40 or more bits of excess information appeared in the data. It so happened that when the craft was struck, 42 bits of excess information were introduced into the network, causing the program to re-calculate. Freier observed, "If there had been, say 39 excess bits, who knows what would have happened to the mission." Since this incident, NASA will no longer launch a spacecraft while there is cloud cover.

Freier's present study ranges from radioactivity in rain to the effect of solar-wind and sunspot activity on the weather, but he has also done extensive work with lightning, its measurable components and its effects on surroundings.

Freier photographs lightning with a special time exposure technique. Using a drum 18 inches in diameter, he spins it at 1,800 revolutions per minute. "The film is wrapped around the drum and exposed during a thunderstorm," he explains. "It is removed when a lightning flash occurs, and then reloaded for another exposure. This spreads out each step of the lightning stroke which can then be analyzed to determine how long each step lasts."

Lightning channel temperatures can be found by analyzing color photographs of lightning. Iron, for example, changes color as it gets hotter, from a dull red to white. Similarly, air temperature can be measured by the type of color spectrum it emits. If the temperature of the air around the lightning channel can be found, then the temperature of the lightning channel itself can be obtained to a near approximation. This is not a definitive method since air is not a solid and the time the air is in contact with the channel is relatively short, but the most common channel temperatures range from 24,000° K to 28,000° K. The extreme temperature range measures from 20,000° K to over 31,000° K.

The diameter of lightning strokes has been found by measuring fulgamites, small raised metal mounds on the surface of copper lightning rods. The base diameters of these mounds have been found to be no more than 0.25 cm in width. This is surprising since the charges transported through these strokes average 3.1 coulombs, as measured in earlier research by D. Muller-Hillebrand.

In the mid-1960s, Martin Uman added a plastic fiberglass cover a short distance above a lightning rod. He observed that the holes produced by the lightning bolts on passage to the rod were of two general sizes. The diameter of these holes ranged between 0.2 to 0.5 cm. and others from 2.0 to 3.5 cm. Since that time use of improved methods of photography has confirmed this fact.

In spite of these advanced research tools and methods, there is much about lightning and its related phenomenon that is still a mystery. For example, we still do not know what ball lightning is. There have been too many verified sightings to doubt the existence of ball lightning, but its physical properties are still unknown and therefore are impossible to duplicate and study properly. Many UFO sightings have been attributed to ball lightning, but that explanation is, in itself, just as mysterious as other explanations, such as visitors from outer space.

When asked about the commonly heard phrase "lightning doesn't strike twice in one place," Freier responded, "If it does it once, it's apt to do it again." Lightning will seek the route of least resistance. If it strikes a tree during one storm, then it would be best not to go near that tree during the next storm. As Robb put it, "The most dangerous place to be during a thunderstorm is outside—anywhere."

People of ancient cultures observed lightning through a fearful eye. Today, drawing from the knowledge gained through the ages, we can view lightning not from a perspective of fear, but one of respect for its impressive power. ■

Jeremy Lanctot is a third year electrical engineering major who has taken to chasing lightning since writing this article. His goal is to become the first person to survive a 200,000 ampere return stroke.

Coming next issue:

- Hazardous Waste and the "U"
- New Coal Scrubber Technology
- Lake Restoration
- Acid Rain

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I.T. Talks About Nuclear Power (Part II)

By Jan Fransen

In the Fall II issue of *Technolog,* we published the results of a survey of I.T. faculty concerning nuclear fission. The results showed that the majority of responding faculty members believe that nuclear fission may be a relatively safe and efficient solution to our energy problems. We thought it would be interesting to see if students held similar beliefs.

Our survey, published in the *I. T. Connection,* was answered by 196 people. Of these, 24 percent were mechanical engineering students, 25 percent were from electrical engineering, and the remaining 51 percent were from other I.T. departments.

In general, the students were a bit more wary of nuclear energy than the professors, but they still showed a high degree of acceptance. They saw nuclear fission as a relatively low cost, clean, safe, and abundant solution to our energy needs. On the other side of the issue, they sited such disadvantages as public fear, waste disposal, and opportunity for human error. Several students pointed out that the Three Mile Island incident was mostly due to human error. On the issue of nuclear waste, one student said, "It's about as close to forever as you can get; half-lives are most often longer than human lives." Another problem is the long-range stability of storage facilities. "Nothing man has ever built has lasted undisturbed as long as nuclear waste facilities must in order to prevent radioactive contamination of the environment," said one student.

Most students felt that the risks involved were outweighed by the advantages. When asked how the United States should proceed with nuclear energy, only 22.8 percent of those responding thought that development should be halted and/or plants dismantled. Many felt that safety would be greatly increased with tighter construction regulations and more highly trained workers. Thus 70.3 percent either agreed or strongly agreed that the risks are acceptable. As one student put it, "Relatively speaking, nuclear power is no more dangerous than any other energy source."

Students backed off a bit when asked if they would live near a nuclear power plant. Yes was the reply of 44.9 percent while 34.5 percent said no and 20.9 percent remained neutral. Most stated that it would depend *how* close or that they would be as willing to live there as by any industry.

QUESTION	PERCENT
1. *How should the U.S. proceed with nuclear energy?*	
Proceed rapidly	27.7
Proceed slowly	48.9
Halt development	13.3
Dismantle plants	9.57
2. *I feel the risks of operating NP plants are acceptable.*	
Strongly agree	32.0
Agree	38.3
Neutral	6.80
Disagree	10.2
Strongly disagree	12.6
3. *Would you be willing to live near a NP plant?*	
Very willing	14.8
Willing	30.1
Neutral	6.8
Unwilling	14.8
Very unwilling	19.7
4. *We have enough knowledge to solve the problems facing the nuclear industry today?*	
Strongly agree	11.2
Agree	32.4
Neutral	16.0
Disagree	22.3
Strongly disagree	18.1
5. *Present NP plants are unsafe.*	
Strongly agree	7.5
Agree	24.7
Neutral	21.0
Disagree	32.3
Strongly disagree	14.5

Pick three of the following which you feel will make the greatest contribution to our energy needs by the year 2000.	**NUMBER**
Biomass	14
Coal	73
Conservation	77
Geothermal	23
Hydroelectric	30
Natural gas	40
Nuclear fission	73
Nuclear fusion	36
Oil	41
Solar	83
Synthetic fuels	28
Wind	21

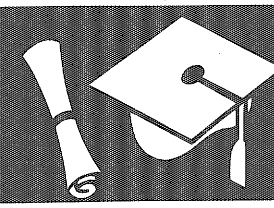
Certainly the nuclear power industry has its problems, but do we have the knowledge to solve them? Among those replying to the survey, 43.6 percent said yes while 40.4 percent said no. Many felt that even though we have the knowledge to solve some of the problems, companies are reluctant to apply it. Others said that the biggest problems are political rather than technical.

Even with the disadvantages, 46.8 percent of those responding felt that present plants are safe, or at least as safe as any other energy source. Some, however, expressed concern about the safety of these plants as they age.

Even though they saw advantages to nuclear fission, many felt that it is only a temporary solution to our energy needs. It has too many inherent problems to be an acceptable long-range solution. When asked what they felt would be contributing to our energy needs by the year 2000, more students voted for solar power and conservation than anything else. Nuclear fission tied with coal for third place. ■

Jan Fransen is an aerospace engineering and speech communications junior. She hopes this unusual combination will allow her to become the world's first intergalactic translator.

The Graduate



By DeAnn Drottz

Many graduates from the Institute of Technology choose to work for large companies within the Twin Cities. The benefits of these jobs vary from company to company, but in general, working for a large company offers several advantages which may not be found in smaller companies. *Technolog* talked to several employees of large Twin Cities corporations and asked them what they felt were some of the main advantages of working for a large company.

The opportunity to advance to more rewarding, responsible jobs in a large corporation is an advantage expressed by several of the people interviewed. Jeff McCutcheon, a recent graduate from the University of Minnesota, works for Magnetic Peripherals Incorporated (MPI) as a chemical engineer. Though he started as an intern for MPI, Jeff has since been promoted to an engineering position. "Five years experience were required for this job, but I was working in the area, I knew formulation and the people.

Employment in a large corporation may also be a source of funding and job security for employees who wish to continue their education. Steve Ginkel is a chemical engineer at Minnesota Mining and Manufacturing (3M). In Steve's field, which involves process design, there is a need for employees to keep up to date with new technology by continuing their education. The concepts and ideas that Steve has recently acquired will be used to improve work conditions in the facility he is building. Remarkable improvements will be made in health conditions and capabilities that will undoubtedly benefit both the company and the people employed there.

Two engineers from Sperry Corporation explained some of the policies of their company. Dr. Jim Babcock is a consultant with a Ph.D. in physics. Jim says that Sperry pays employees to continue their education and allows time off from work for attending classes. More education may result in salary increases. Greg Christner, who also works for Sperry, indicated that while some provisions are made to continue one's education, the most desirable job applicants should still have a background in the area they wish to work.

MPI is cooperative about allowing full-time employees time off from work to continue their education and will pay for coursework that is applicable to the job that an employee is performing. Jeff McCutcheon said that employees at MPI are expected to continue their education and that in the six months he has been there he has already attended two seminars.

Thinking Big at Graduation Time?

Another desirable feature of working for a large corporation is the large variety of modern equipment available for use. Phil Radtke, a chemist at MPI, works in the analytical laboratory. He is pleased with his job because he has been able to work on a gas chromatograph and done much work with infrared spectroscopy. Greg Christener picked his job at Sperry because, although there are three or four companies in the Twin Cities which are involved with thin film processing, Greg can use processing techniques not available at other companies.

There are several other pluses to working for a large company. One is the possibility of traveling to other states or even other countries to perform duties related to the job. Another benefit is the existence of a wide variety of work groups which give an employee a greater chance of obtaining work with the people, projects and management that are most desirable to him or her. A third advantage, of course, is a good salary that gives most scientists and engineers a fairly comfortable living.

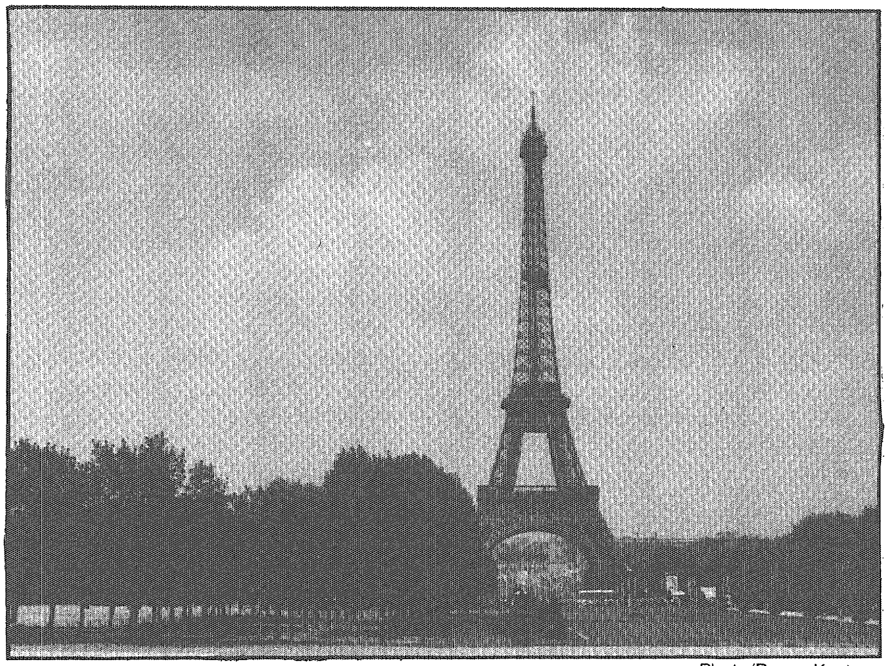
Although the positive aspects of working for a large company should be taken into consideration by the graduating scientist or engineer, he or she should not forget that personal satisfaction almost always depends upon the type of work one is doing. By far the majority of people interviewed stated that the satisfaction they obtained from the work they were doing was the main reason they liked their jobs. Each position with each company, whether large or small, must be individually examined to determine whether it meets one's personal standards.

As the economy improves, new graduates should consider some of the good points of working for a large company. The chance to advance, to have the company pay for the furthering of one's education, and the wide variety of modern equipment available are just a few of the many

Continued on page 24

Tour of Industrial France: A Student's Perspective

By Charles B. Goodrich
and Lawrence R. LaPorte



Photo/Renee Kostner

As we stood and read the bulletin board in the basement of Lind Hall we could not believe our eyes. It seemed to be an incredible offer—an all expense paid one-week internship in Paris and surrounding France. We considered this amazing offer approximately ten seconds after which time we immediately proceeded to the International Study and Travel Center (ISTC) to hear more. Further details outlined a tour of industrial France to celebrate two hundred years of science and technology at Ecole des Mines, a prestigious engineering school in Paris, France. Two hundred sixty students from around the world were to gather at the school in Paris and, after a brief orientation, break into groups of approximately twenty and depart for the area of France that each student had chosen prior to arrival. The celebration was supported by French industries and implemented by Ecole des Mines with the dual purpose of exposing French industry to students with an interest in international affairs and to commemorate two hundred years of registration, class schedules, and finals at Ecole des Mines. Invitations were sent to top engineering and science universities throughout the world to attract an international group of students. The opportunity to become a part of this international event motivated us to endure the lengthy application process, and much to our elation, we were accepted.

This was to be the first trip abroad for both of us, and the two months preceding our departure were filled with anxiety and anticipation. As the details of our overseas trip were attended to, these feelings of apprehension increased until we found ourselves on a cramped, overnight, trans-Atlantic flight. Air France provided many students with tickets for flights on the Concorde, however we were not fortunate enough to be part of this program. Our feelings of despair were short-lived, however, when we arrived in Paris and immediately set out to tour the city.

One of the highlights of our stay took place within hours of reaching downtown Paris. We were enjoying a quiet moment and the view from the roof of the Cathedral of Notre Dame when the solitude was suddenly broken by the sighting of a strange aircraft on the horizon. As it climbed within view, we both experienced what we thought was a severe case of jet lag. We speculated as to its origin until its unusual shape started to take form. The aircraft was a 747 carrying a space shuttle on its back. As the Sunday afternoon crowd "oohed" and "aahhed" we recalled from news reports that the international air show was being held in Paris this week. No sooner was this realized than our 35mm camera was subjected to abusive handling in the loading and unloading of approximately three rolls of film. An extremely lucky coincidence allowed two amateur photographers to boast of having more pictures of the space shuttle Enterprise in the foreground of the Eiffel Tower than many professional photographers.

Our enthusiasm renewed, we arrived at the university and, contrary to our handling at the airport, were greeted with much warmth and acceptance by our French hosts. The informal orientation was all too brief as we had little time to meet everyone and at the same time sample the food that was laid out in a manner resembling a feast fit for a king. Time was very critical in this week-long whirlwind tour. We no more than finished eating when we were told to report to our group's tour guide. He was a short, little Frenchman with curly hair and was a graduate student at Ecole des Mines. He reminded us of the character on the old television show Hogan's Heroes, so we nicknamed him Le Beau.

Our tour was one of thirteen different tours that had been put together by the school. Each tour featured itineraries varying in both location and topic. Nuclear power plants, computer and telecommunications industries, the air show, and mineral and ore mines were just some of the tours that were located in every industrialized part of France. Each student had the opportunity to choose the tour that interested him or her most. Our tour took us to the Cote d'Azur (the blue coast) in the region surrounding Nice.

The bus ride to the ultra-modern Charles de Gaulle Airport and our subsequent flight to Nice gave us our first opportunity to meet the others in the group. Our group was comprised of students from Canada, Belgium, Norway, West Germany, Sweden, Japan, Czechoslovakia, and the United States. At this time we felt the need to adopt a common language for communication. Only half the group spoke any French (it was not a prerequisite and yes, this did cause memorable moments). To our surprise, everyone spoke English, so we chose it as the official language of our group.

The flight from Paris to Nice signified what we thought was the end of the hectic first part of our journey. We soon found that this was not so—everyday was to be just as exciting and hectic as our first day. The second day began at the branch campus of Ecole des Mines located near Nice in an industrial park called Sophia-Antipolis. We spent most of our mornings in Sophia-Antipolis touring the various companies and corporations located there. The concept for an industrial complex like this was conceived by Pierre LaFitte, dean of Ecole des Mines. Developed with the aid of the French government and named after Pierre's first wife, Sophia, the park has achieved considerable success. The close proximity of other businesses and the availability of the branch university campus with its research capabilities are the primary reasons for its success (not to mention being located on the French Riviera).

One of the first differences we noticed between France and the United States was the lack of a broad range of schools in France as there are here. There are, of course, the top universities like Ecole des Mines, but aside from schools of this type the only other technical training available is at the trade schools which would be similar to the United States' vocational school system. In France it is quite a privilege to attend a university—a privilege which must be earned.

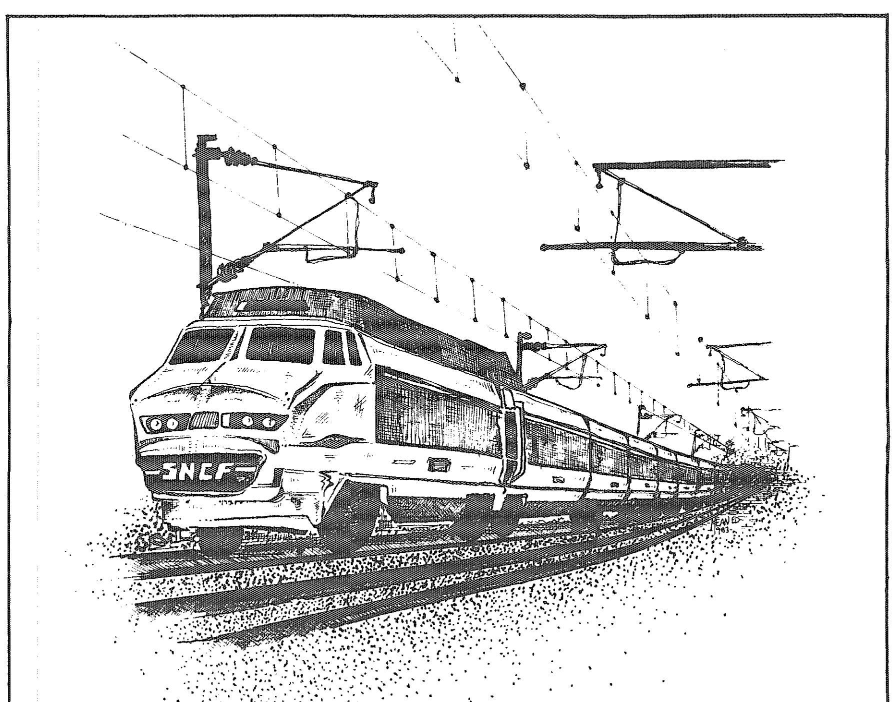
The average student at Ecole des Mines does not graduate after the normal four year period. Rather it is common to proceed with schooling until one achieves a level of education comparable to our Master's or Ph.D. degree. Also surprising to us was the idea that students should not participate in industrial internships as part of their education. Many professors and businessmen did not seem to realize the full potential available to both parties.

In a typical day we would rise at 6:30 and meet for breakfast by 7:00. Traditional French hotels, like the one in which we stayed, are small (20 to 30 rooms) and serve three meals a day to their patrons. Breakfast was always simple—coffee and rolls with butter and jam. We found it gets somewhat repetitive after a few days, but when in France, do as the French!

After breakfast we would board a bus for a ride that would last anywhere from thirty minutes to two hours. Most of the mornings we toured companies in Sophia-Antipolis, but sometimes we would go to other locations in the area. After a tour of the plant we would be guests of honor at the company cafeteria. Not surprisingly, French workers looked, behaved, and were treated similar to American workers. One exception may be the length of the work week—only 38 hours as a result of the new socialist government.

After lunch we would board our bus and head for a destination that was usually inland toward the foothills of the Alps. One afternoon we visited a perfume factory and learned just how technical the process of making various perfumes and colognes could be.

Other afternoons were spent



inspecting a bauxite mine visiting various art galleries, touring a two hundred year old French vineyard and touring a twelve hundred year old French monastery. Following the afternoon tour would be a dinner at a French inn in the country or one of the glittery restaurants back in town. Typically we would return to the hotel in the early evening and plan on an exciting night out in Nice or nearby Monte Carlo but usually we were too exhausted.

During our tour we sensed a certain French adulation toward new technologies. In one resistor factory named Sfernice, a new computer-guided laser cut resistors at precisely the right time in order to achieve a resistor that was within a specified value. Our tour guide and the employees glowed with an increased sense of pride when they exhibited their new machines. Certainly this is not a uniquely French reaction. However, what is interesting is that this particular technology is not new. It has most probably been used in the United States for five years or more. These employee reactions along with other opinions given to us tend to indicate that the bulk of the French companies are in older, more mature industries. This may change, however, with the French government targeting certain industries and leaving these older industries to fend for themselves.

One exception to this daily routine came midweek when we visited an IBM plant. We were tired due to the past days' hectic pace, but we started the morning with the anticipation of touring an American corporation in Europe. It proved to be the highlight of the week. This opportunity to compare and contrast an American-style company operating in a foreign land with the companies we previously toured proved very enlightening. Upon arriving at the plant we were immediately struck with a difference. Our guide was professional in every aspect and catered to our needs and curiosity. We surrendered our cameras at the door as at most companies and proceeded through a brief outline of the day's activities.

The points that set IBM apart from other French hi-tech firms were its marketing and public relations departments. Although the other firms we visited were smaller (such as Thomson C.S.F., Air France) they did not seem to meet the same professional levels as IBM. Employee relations, comforts for workers, and a total commitment toward its workforce were the practices that provided IBM with its winning edge. This idea of dynamic management with full medical benefits and ample vacation time again set apart IBM from its French contemporaries. The tour was also much more interesting due to the guide's ability to make concessions to the group. Following the tour of the plant, we held a brainstorming session that was the intellectual highlight of the tour. We examined issues important to France and its level of technology, and the answer always came back to good communication with other international companies.

Following the tour we went home and prepared for a night at the ballet and the dinner which was to follow. This was IBM's way of showing that they follow up on the ideas they preach.

At the end of our seven days in Nice we returned to Paris for a final reception at the French Senat (senate). It had all the pomp and circumstance of any diplomatic event. Again we were presented with a banquet of pastries, cheeses, and many other uniquely French delicacies. The occasion included speeches by members of the Senat, Pierre LaFitte and several of the students on the tour. It was a grand occasion and in many ways symbolic of the status of French technology. Once a premier power on their continent and in the world, they must adapt to other technological methods in order to retain their standing in the world. But they are willing to make the necessary innovative changes (such as this internship) which will enable them to keep their status. Most certainly, we are happy they did. ■

Charlie Goodrich is an aerospace engineering senior and **Larry Laporte** is an industrial engineering senior. Both were so impressed by their internships in France that they are currently checking into the possibility of obtaining one-week internships in Daytona, Florida over spring break.

Ad Astra

By Scott Otterson

The Robots Of Dawn, Isaac Asimov, Doubleday, hardcover, 419 pages, $15.95.
Computer Dictionary For Beginners, Arthur Naiman, Ballantine, paperback, 150 pages, $8.95.
The Hacker's Dictionary, Harper & Row, paperback, 139 pages, $5.95.

Science fiction fans will be happy to hear that **Isaac Asimov** has come up with another addition to his long line of robot stories. ***The Robots Of Dawn,*** the latest in the Lije Baley series, is nothing wildly original, but Asimov's intricate plotting and usual craftsman-like style make the book eminently readable.

The uncannily human masterpiece of the planet Aurora's best roboticist has been cleverly "murdered" and its politically controversial creator, who admits that he is the only possible suspect, engages fading, middle-aged Earth detective Elijah Baley to prove his innocence. Baley, the agoraphobic product of the paranoid and prudish society of billions that infests the Earth in cramped underground cities, is expected to solve the crime on Aurora, a comparative Eden of promiscuous free spirits who regard Earth people as disgusting and even dangerous. With uncooperative witnesses and a questionably motivated client, the detective is in a tough spot.

About the only sure thing in this case is the constant logic of robot behavior and, as in most of Asimov's robot stories, the solution to the mystery lies in a careful thinking through of the immutable Three Laws Of Robotics. But there are added considerations; like everything else on Aurora, the murder in question involves sex. The humanoid robot was once the "husband" of a beautiful and sexually troubled acquaintance of Baley's, so to make sense of this mess, Baley must not only make his way through a complicated tangle of robot logic and unfamiliar Auroran politics, but he must also understand the equally unfamiliar territory of the woman's confused emotions.

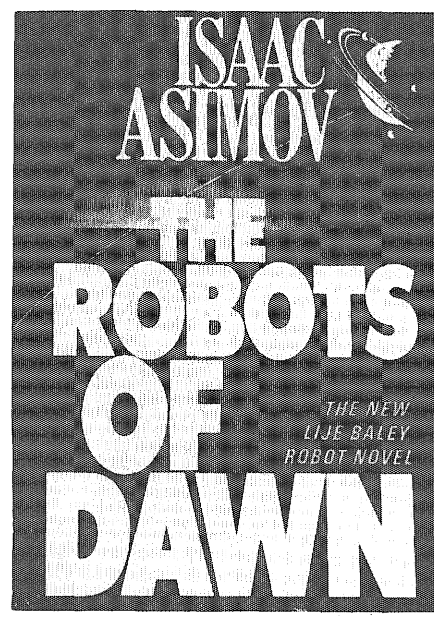
The Robots Of Dawn leaves the reader with the impression that Asimov is as uncomfortable with sexual emotions as Baley is, for the detective's relationship with the woman is somewhat awkward and talky. On the other hand, their association does set up tensions that keep the book interesting, and its bittersweet termination brings the story to a satisfying conclusion.

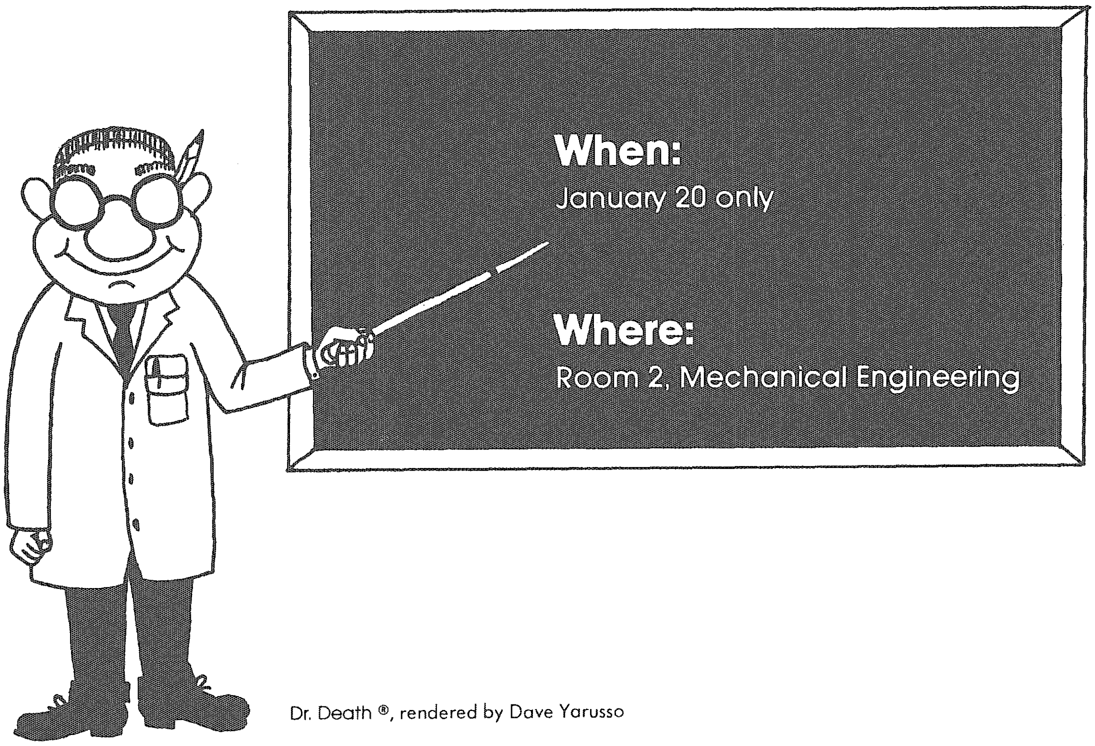
Finally! A pair of paperbacks for bookworms who have been unjustly accused of reading dictionaries and who feel the perverse need to make good on that accusation:

Computer Dictionary For Beginners is just that. Written for the novice, it defines more than a thousand computer terms like "DIP," "dump," and "Lord Babbage." Photographs, illustrations and wit make the book "user friendly," and flipping through it isn't as boring as one might expect.

For the more—uh—enthusiastic there is ***The Hackner's Dictionary,*** a collection of computer slang from the celebrated CRT's of MIT, Stanford, and the like. The peculiar culture of those fanatics who have lately taken to bursting into national defense files, along with bits of their idiom like "frobnitz," and "laser chicken," is humorously explained with geeky enthusiasm.

"Glork! A Glossary for gweeps," *Time Magazine* warbles slavishly in a cover quote. "Even users should grok this cuspy sample of computerese..." That's a very "klib" thing for an uninvolved reviewer to say, but for those of us who in fact work in technical fields and fancy that we will retain a shred of normality, *The Hacker's Dictionary* may be a reminder of the secret fear that each of us carries as a nightmare buried deep in the subconscious: the dread that we might wake up some morning and actually start talking like this. ■





Dr. Death ®, rendered by Dave Yarusso

Doctor Death (the guy that writes the notorious **Technolog** crossword puzzles) says that you really ought to have your picture taken for the I.T. Yearbook — or else.

Fortunately, I.T. Yearbook picture sessions are free; check board for time and date.

1983 CONTINUUM 1984

Technotrivia ???

By L. Phillip Gravel III

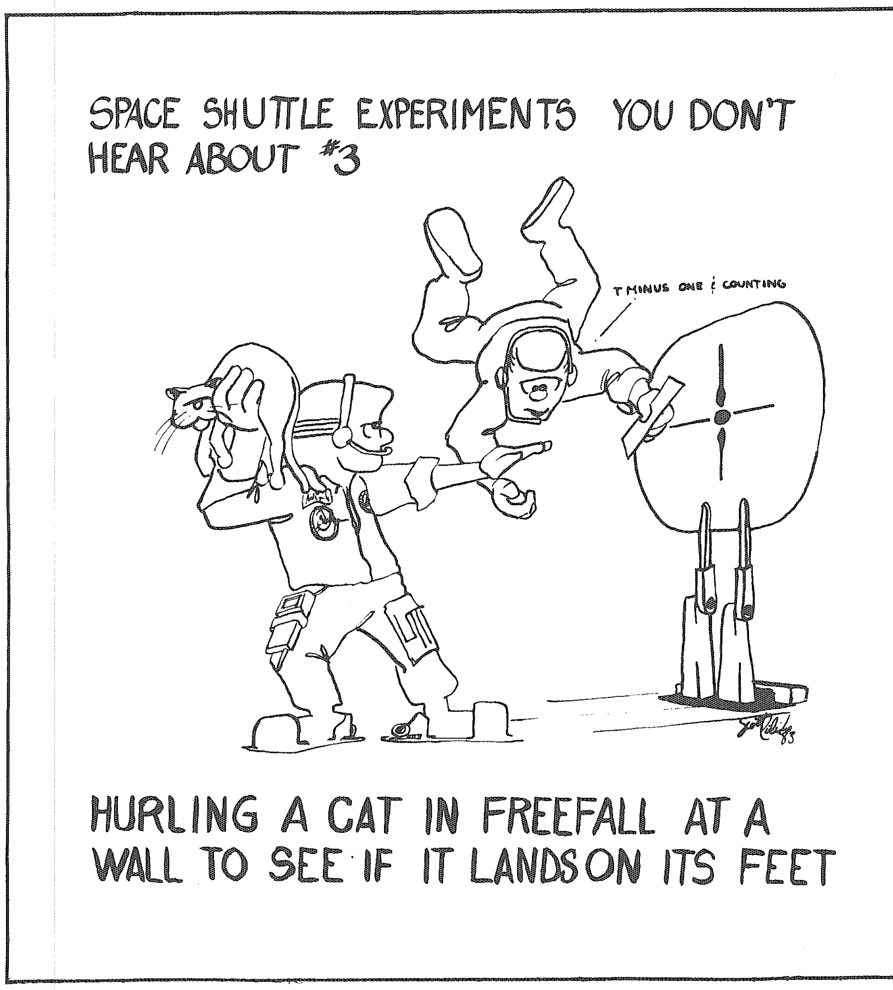
1. Henri de la Fuerte of France is highly regarded for his ability to undress down to his socks in six seconds flat. If you are struck by lightning you may very well have your clothes and shoes thrown off in even less time. What causes this quick-strip?

2. When was the first electronic computer introduced?

3. Undoubtedly you have run across a Bernoulli theory or equation more than once in your classes. Have you ever wondered who this Bernoulli was? Actually there was an entire battalion of Bernoullis making scientific discoveries in the 17th and 18th centuries. Brothers Jakob and Johann and their sons Daniel and Bikolas were the more prominent of the Bernoulli mathematicians. One of these gentlemen derived the method of solving limits which we know as L' Hopital's Rule. (The rule was first published in a book by L' Hopital, and thus it is referred to as his rule.) Which of these long-haired men was really the discoverer of L' Hopital's rule?

4. What is the coldest place in the world on the basis of annual mean temperature, and what is that temperature? Hint: This place makes Minneapolis look like the tropics. Secondly, where was the highest annual snowfall recorded?

5. Sand and studded tires are both used in winter driving on icy streets. Why is it that neither helps much if the temperature is below 0° F?

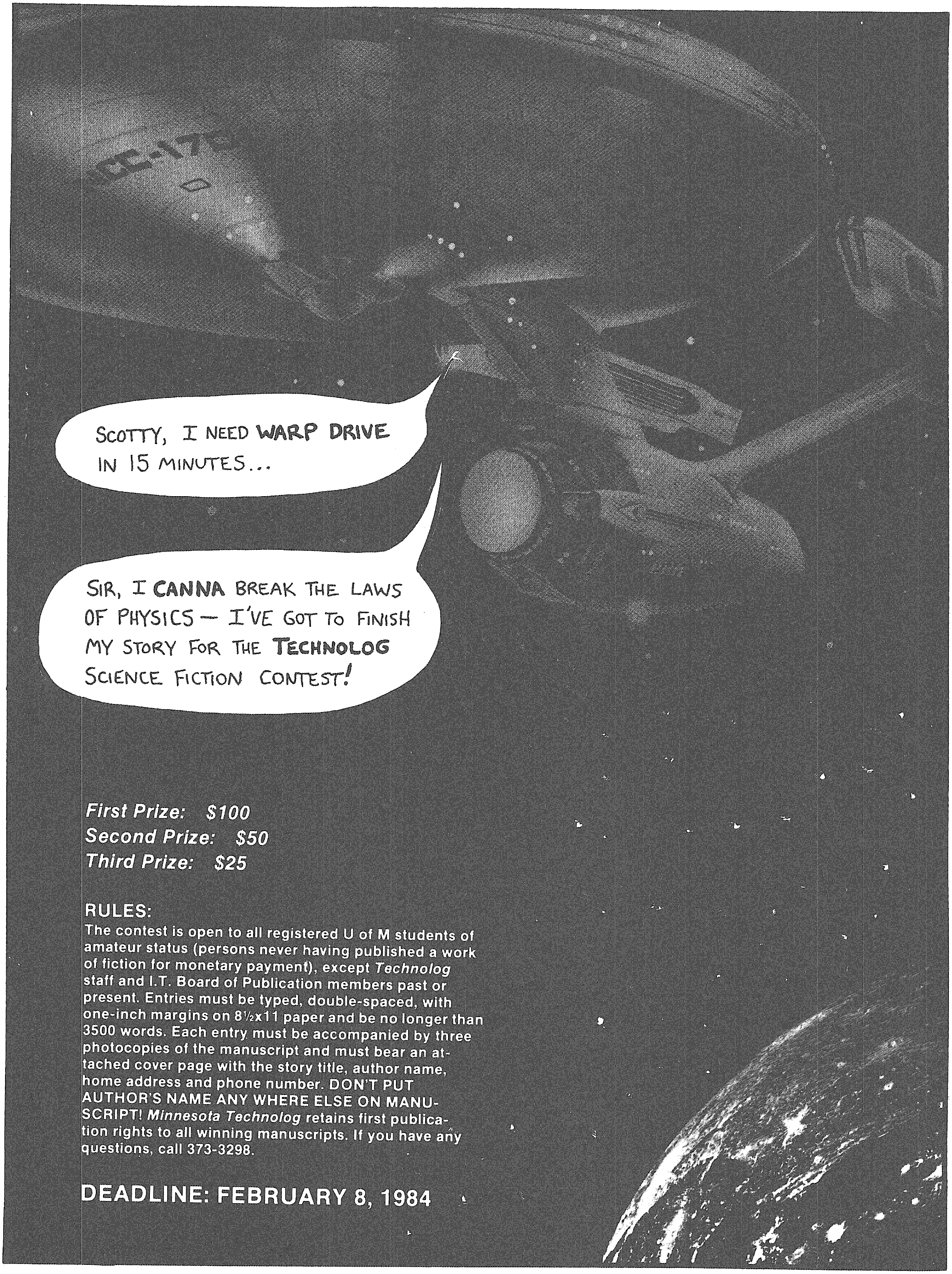


6. Minerals may be classified according to the Mohs Hardness Scale. On this scale ten well known minerals are used as reference points. Talc is given a hardness of 1 while diamond is given a hardness of 10. In what order do these three minerals appear on the Mohs scale: calcite, apatite, and quartz?

7. Which color has the shorter wavelength, violet or red?

8. Here's one for computer heads. This user interface was first introduced by Xerox. It was previously found only on expensive equipment until Apple Computer made it part of their new computer, Lisa. The device is called a mouse. What does it do?

Trivia answers on page 24



First Prize: $100
Second Prize: $50
Third Prize: $25

RULES:

The contest is open to all registered U of M students of amateur status (persons never having published a work of fiction for monetary payment), except *Technolog* staff and I.T. Board of Publication members past or present. Entries must be typed, double-spaced, with one-inch margins on 8½x11 paper and be no longer than 3500 words. Each entry must be accompanied by three photocopies of the manuscript and must bear an attached cover page with the story title, author name, home address and phone number. DON'T PUT AUTHOR'S NAME ANY WHERE ELSE ON MANUSCRIPT! *Minnesota Technolog* retains first publication rights to all winning manuscripts. If you have any questions, call 373-3298.

DEADLINE: FEBRUARY 8, 1984

TechnoFlog

By Stephen MacLennan
Al Hauser

Note on door of 8:00 physics class:

A body in bed tends to stay in bed. Who says physics can't be applied to the real world!

Chem professor: "Name a liquid that won't freeze."
Chem student: "Hot water."

An EE, after looking over a selection of thermometers, told the supply shop manager, "I'll take this Fahrenheit one. I know that's a good brand."

"His mind is as good as new! Of course, it should be; it's almost never been used."

One day Leif and Woody, two forestry students, decided to go duck hunting. They found a landowner who let them use his dogs and hunt on his land. After a long day without any luck, Woody said, "Leif, that sure was nice of that man to let us use his dogs and hunt on his land. I wonder why we didn't get any ducks, though."

Leif thought for a moment and said, "Maybe we weren't throwing the dogs high enough."

The Quick Strip

The worst thing about history is that every time it repeats itself the price goes up.

"You'll be poor and unhappy until you graduate from college," said the fortune teller to the engineer.
"And then what?" asked the engineer hopefully.
"You'll be used to it by then," answered the fortune teller.

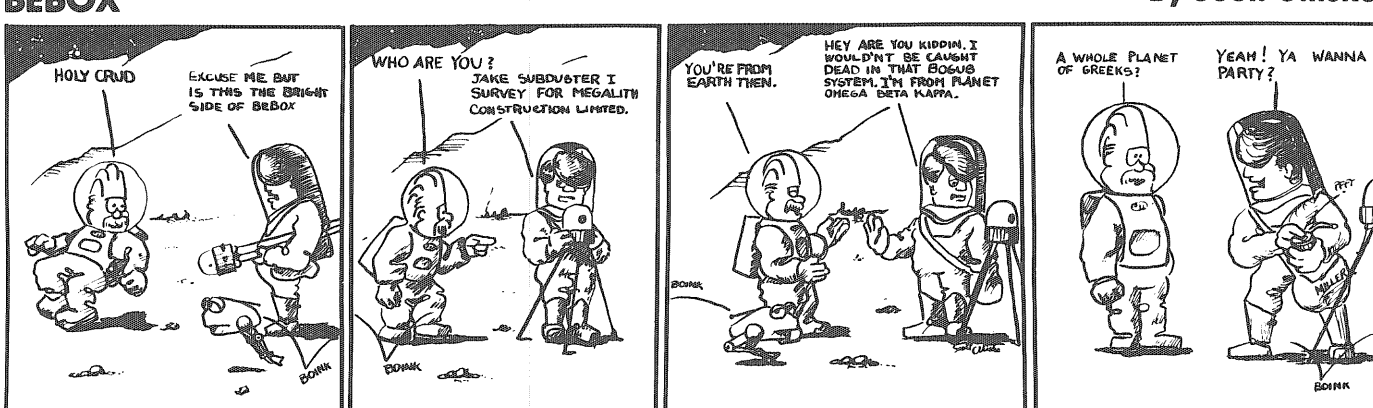
Brain Teaser

Five criminals appeared before Judge Fate for sentencing. Their names, strange to say, were Mr. Libel, Mr. Fraud, Mr. Blackmail, Mr. Theft, and Mr. Murder—each a namesake of the crime with which one of the others was charged.
The namesake of the crime with which Mr. Blackmail was charged was himself charged with the crime of which the namesake was charged with murder; the namesake of the crime with which Mr. Murder was charged was himself charged with the crime of which the namesake was charged with fraud.
Mr. Theft was not the murderer. Who was? And what crimes did the others commit?

Brain teaser solutions on page 24

BEBOX

By Scott Ciliske



Brain Teaser Solution

1. Mr. Blackmail committed x; Mr. X committed y; Mr. Y committed murder.
2. Mr. Murder committed z; Mr. Z committed w; Mr. W committed fraud.
3. Neither Mr. Murder (same name), Mr. Blackmail (from 1 above), nor Mr. Theft could have been charged with murder.
4. Assume that Mr. Fraud is charged with murder. Then y=fraud, and we have: Mr. Blackmail committed x; Mr. X committed fraud; Mr. Fraud committed murder.
5. Combining 4 with 2 above, we see that x=w and b=z. This gives us: Mr. Murder committed blackmail; Mr. Blackmail committed x; Mr. X committed fraud; Mr. Fraud committed murder. This is a closed circle containing only four people, leaving the fifth person to be charged with the same crime as his name. Since this can't be, it follows that Mr. Fraud cannot be charged with murder and that Mr. Libel must have been the murderer. (That scoundrel!)
6. Now Mr. Blackmail committed x; Mr. X committed libel; Mr. Libel committed murder.
7. The only way this sequence can combine with 2 above is for x=fraud. This implies w=blackmail and z=theft and thus the total solution is: Mr. Murder committed theft; Mr. Fraud committed libel; Mr. Libel committed murder.

Technotriva Answers

1. The rapid evaporation and the expansion of the moisture on your skin blows off your clothes and shoes. You may otherwise be unharmed if little of the current enters your body. Source: Jearl Walker, *The Flying Circus of Physics,* John Wiley & Sons, Inc., New York, 1977.

2. The first electronic computer was the Electronic Numerical Integrator and Computer (ENIAC) developed for the U.S. Army Ordnance Dept. in 1946. The device weighed some 30 tons and contained over 18,000 vacuum tubes and semiconductor diodes as well as 1,500 relays. Source: Patrick Robertson, *The Book of Firsts,* Rainbird Books, London, 1974.

3. Johann Bernoulli (1667-1748) sent the method to L' Hopital in 1698. Source: *Encyclopedia Britannica,* Volume 2, Chicago, 1974.

4. Coldest place: Pole of Cold, Antarctica (78° S, 96° E) with an average temperature of -72° F. Most snow: 1000.3 inches of snow fell on Mount Rainier, Washington in 1955-56. The annual average there is 575 inches. Source: Norris and Ross McWhirter, *Dunlop Encyclopedia of Facts,* Bantam Books, New York, 1969.

5. Studded snow tires and gravel depend on the melting of the ice and snow beneath them. Even if the temperature is below freezing, the increased pressure from the weight of the car will allow melting. However if the snow and ice are below 0°F, the increased pressure is insufficient to cause melting. Source: Jearl Walker, *The Flying Circus of Physics,* John Wiley and Sons, Inc., New York, 1977.

6. The minerals are classified as follows: calcite, 3; apatite, 5; quartz, 7.

7. The violet wavelength ranges from approximately 400 to 450 nanometers. Red ranges from 650 to 700nm. Both have a frequency of about 10^{14} Hertz. Source: Zemansky, Young, and Sears, *University Physics Fifth Edition,* Addison-Wesley Publishing Co., 1976.

8. The mouse is a pointing device which allows the user to move the cursor on the screen without typing. On Lisa the mouse is a box on a long wire which moves the cursor as it is rolled across a flat surface. Source: "No Cursors, No Curses," *Newsweek* October 3, 1983.

Score

0-1 Next time read the answers first and then see how you do.

2-3 Only an engineering approximation from greatness.

4-5 Greatness.

6-8 Is it lonely at the top?

The Graduate from 15

advantages offered by a job with a large company. With some hard work and a little luck, you too could join the ranks of the many people already enjoying these benefits.

In Winter II Technolog *will examine some of the advantages of working for a small company in "The Graduate."*

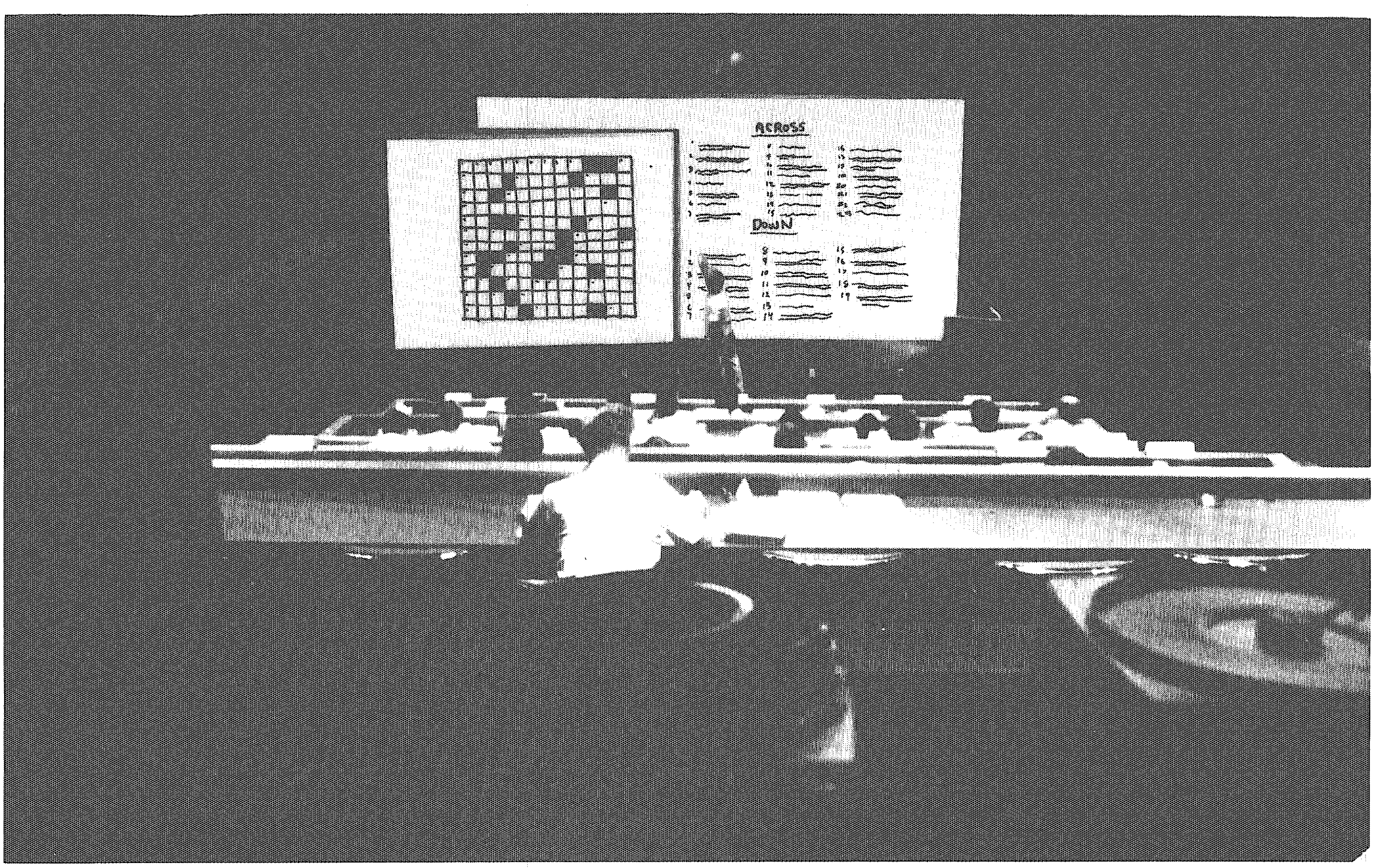
Technopuzzle

By Mark "Dr. Death" Stolzenburg
Diabolical Dan Rader
Scott "the Scourge" Fruin
Abominable Al Hauser

Welcome to another exciting episode of "Technopuzzle." Recall that at the end of last issue the demented Dr. Death and his crew of crafty cronies left the *Technolog* readership with an unsolvable puzzle. All appeared lost until Clark Pansch, a junior computer science major, came to the rescue and submitted the puzzle solution to the authorities in Room #2, Mechanical Engineering. He was awarded a prestigious "Do I.T. with an Engineer" T-shirt and will surely be remembered as one of the great heroes of our time. But wait, the diabolical Dr. Death has recently returned from the depths of disgust and depravity with another puzzle more difficult and challenging than the previous one. This time his twisted mind has contrived a set of words and clues with a common theme of computers. Is all lost? Or will the forces of good within I.T. rise to greatness once again? The first gallant person appearing in Room #2, Mechanical Engineering, with the correct solution to the puzzle may claim a "Do I.T. with an Engineer" T-shirt as his/her just reward. Good luck on your quest and Godspeed!

Fall 2 Technopuzzle solution

^{1}E	^{2}N	^{3}D	^{4}O	^{5}T	^{6}H	E	^{7}R	^{8}M	^{9}A	L	■	■	^{10}B	^{11}S
^{12}L	O	O	N	E	Y	■	^{13}C	A	R	■	^{14}P	^{15}E	A	T
^{16}E	R	G	■	^{17}L	D	^{18}R	■	^{19}P	E	^{20}D	A	L	■	E
^{21}C	T	■	^{22}N	O	R	A	^{23}D	■	^{24}N	O	N	E	^{25}N	E
^{26}T	H	E	R	M	O	D	Y	N	A	M	I	C	A	L
^{27}R	E	■	■	^{28}I	E	I	A	■	■	^{29}A	C	T	S	■
^{30}I	R	^{31}O	^{32}N	C	L	A	D	■	^{33}F	I	■	^{34}R	A	^{35}F
^{36}C	L	A	Y	■	^{37}E	L	■	■	^{38}A	N	^{39}S	I	■	I
^{40}B	Y	■	■	^{41}B	C	■	■	^{42}P	U	■	^{43}T	C	■	S
A	■	^{44}P	^{45}H	O	T	^{46}O	^{47}V	O	L	T	A	I	C	S
^{48}T	^{49}C	■	^{50}C	I	R	C	U	I	T	■	^{51}R	T	■	I
^{52}T	R	I	■	^{53}L	I	E	■	■	■	^{54}S	T	I	L	L
^{55}E	E	■	^{56}D	E	C	A	^{57}A	^{58}M	^{59}P	E	R	E	■	E
^{60}R	T	^{61}D	■	^{62}R	A	N	D	O	M	N	E	S	^{63}S	■
^{64}Y	E	A	R	■	L	■	^{65}C	S	■	^{66}D	K	■	^{67}I	O



Computer Madness

Across

1. Sum

4. e.g. Boolean

8. Computer fruit

12. Southeast Asian language

13. Display devices

17. Lowest point

18. Kanga's kid

19. Measure of data density (abbr.)

20. Social club (abbr.)

22. ______-processor (abbr.)

23. Metal pesticide (abbr.)

24. Hydroxylated hydrocarbons

29. Counterweight

30. Communicating at high baud rate

32. Computer power (abbr.)

33. Source of intuition

34. Great magazine (first syllable only)

35. New national game

38. Something you don't get playing on a computer

39. I.T. language

41. After ed.

44. e.g. water, alcohol (abbr.)

45. BASIC command

46. Loyalist

48. Harper Valley

49. FORTRAN relational operator

50. Agency which polices nonoctal dumps (abbr.)

52. Of Oxford (abbr.)

55. Needed to log onto 35 across

57. ______-net

59. Business college language

62. Computer record player

64. Enforces game rules (abbr.)

65. Disk operating ______

66. Play

Down

1. Nuclear watchdog (abbr.)

2. Laboratory computer task

3. Side sheltered from wind

4. Fire ______

5. Page designs

6. BASIC directive

7. Type of memory

9. The third degree (abbr.)

10. Hawaiian food

11. Leader (abbr.)

14. Not digital

15. Responsibility of 50 across (abbr.)

16. Site of computer boom

21. To neophytes, computers may seem ______.

23. Characteristics

24. The editor

25. Put prefix

26. Half a laugh

27. Computer base

28. ______ of Wom. Eng.

31. Channels greater than 13

32. Apportioned

35. Cassetteless image storer (abbr.)

36. What one does with a computer class

37. Heart of computer (abbr.)

38. Magnetic medium

40. Translucent rock

42. Birthplace of J. Daniels (abbr.)

43. Computer/Human interfaces (abbr.)

46. ______ peripherals can cause time-out errors.

47. Overload (EE slang)

49. Computer metal

51. Wages

53. Government agency for civil and defense mobilization (abbr.)

54. ______-gate

55. Element named for state (abbr.)

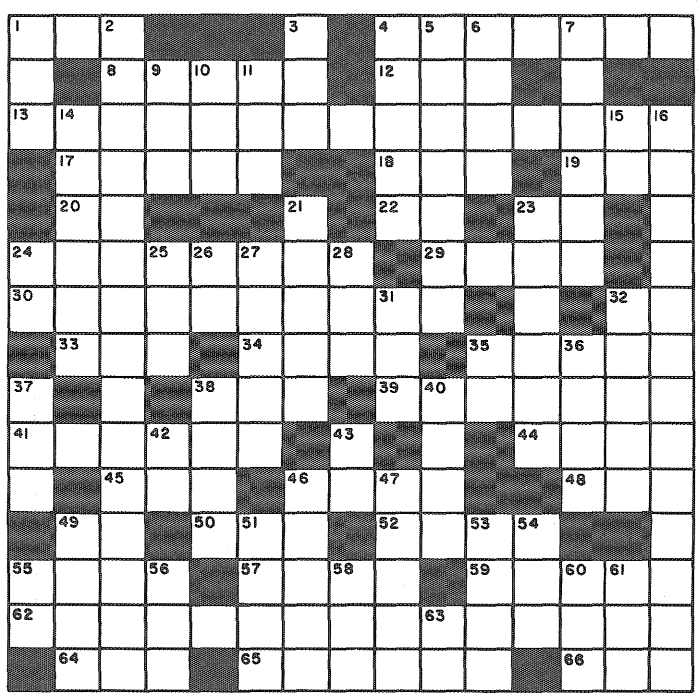
56. "Companion's" home (abbr.)

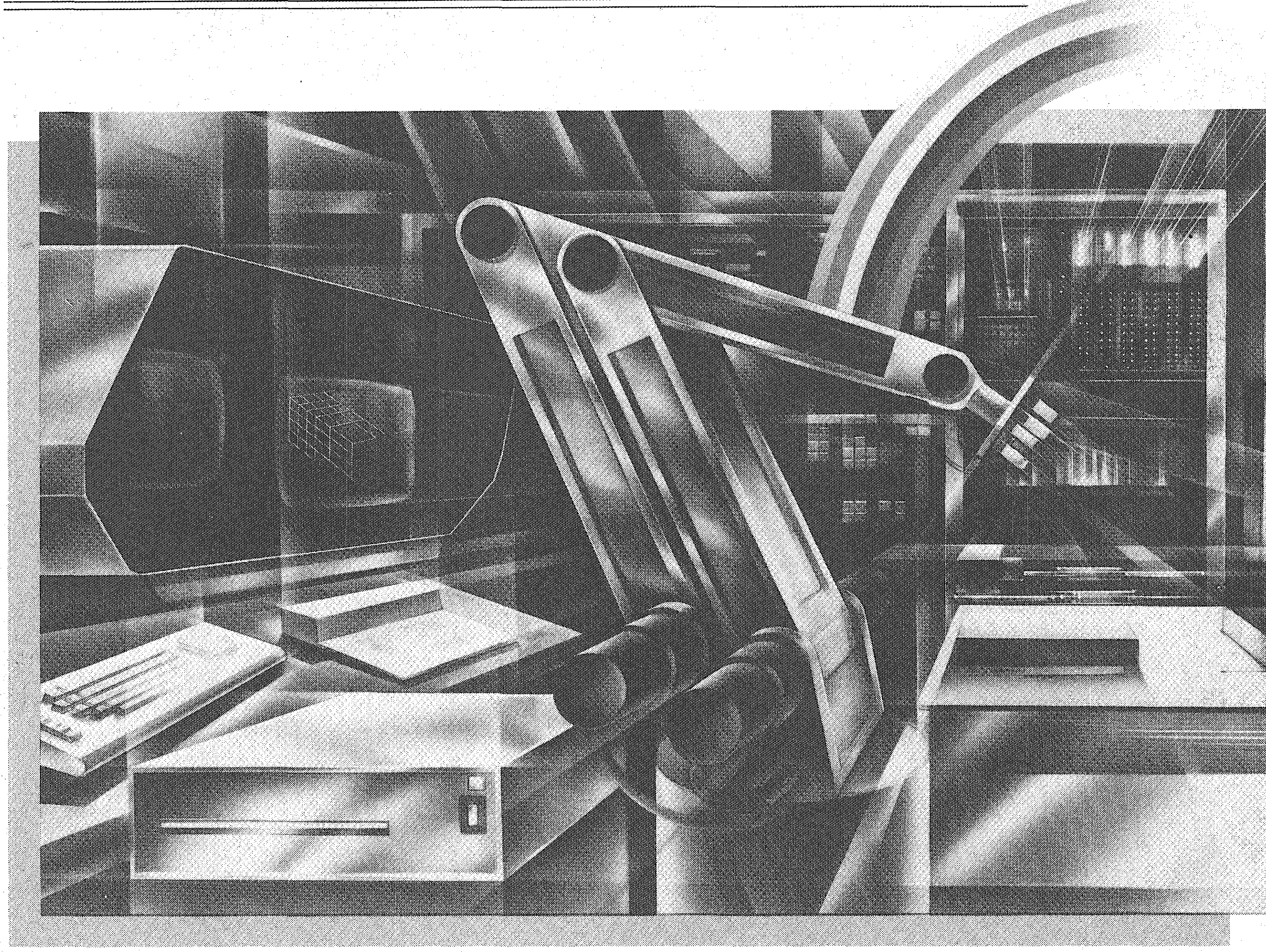
58. -i x ln(-1) (pl.)

60. Data quantum

61. Egg (prefix)

63. Type of energy (abbr.)





Convert the production line into a frontier of creativity.

The cast-iron technology of the factory will soon be silicon technology.

Chips and computers transfer design information directly to the factory floor. Other chips make possible flexible robotics, programmable controllers for machine tools, automated test systems and digital inspection cameras. Local area networks tie together all these systems.

These are revolutionary changes that can result in better-made products, manufactured of new materials at lower cost.

GE is deeply involved in bringing manufacturing into the silicon age. In one plant, electronics and computer systems enable us to reduce production time of a locomotive's diesel engine frame from 16 days to 16 hours. At our dishwasher production plant, a master computer monitors a distributed system of programmable controls, robots, automated conveyors, assembly equipment and quality control stations.

We're working on robots that can see, assembly systems that hear, and machinery that can adapt to changes and perhaps even repair itself.

This transformation of manufacturing from the past to the future creates a need for new kinds of engineers to design and operate factories of the silicon age. They have to be as familiar with the realities of the assembly line as with the protocols of software communications.

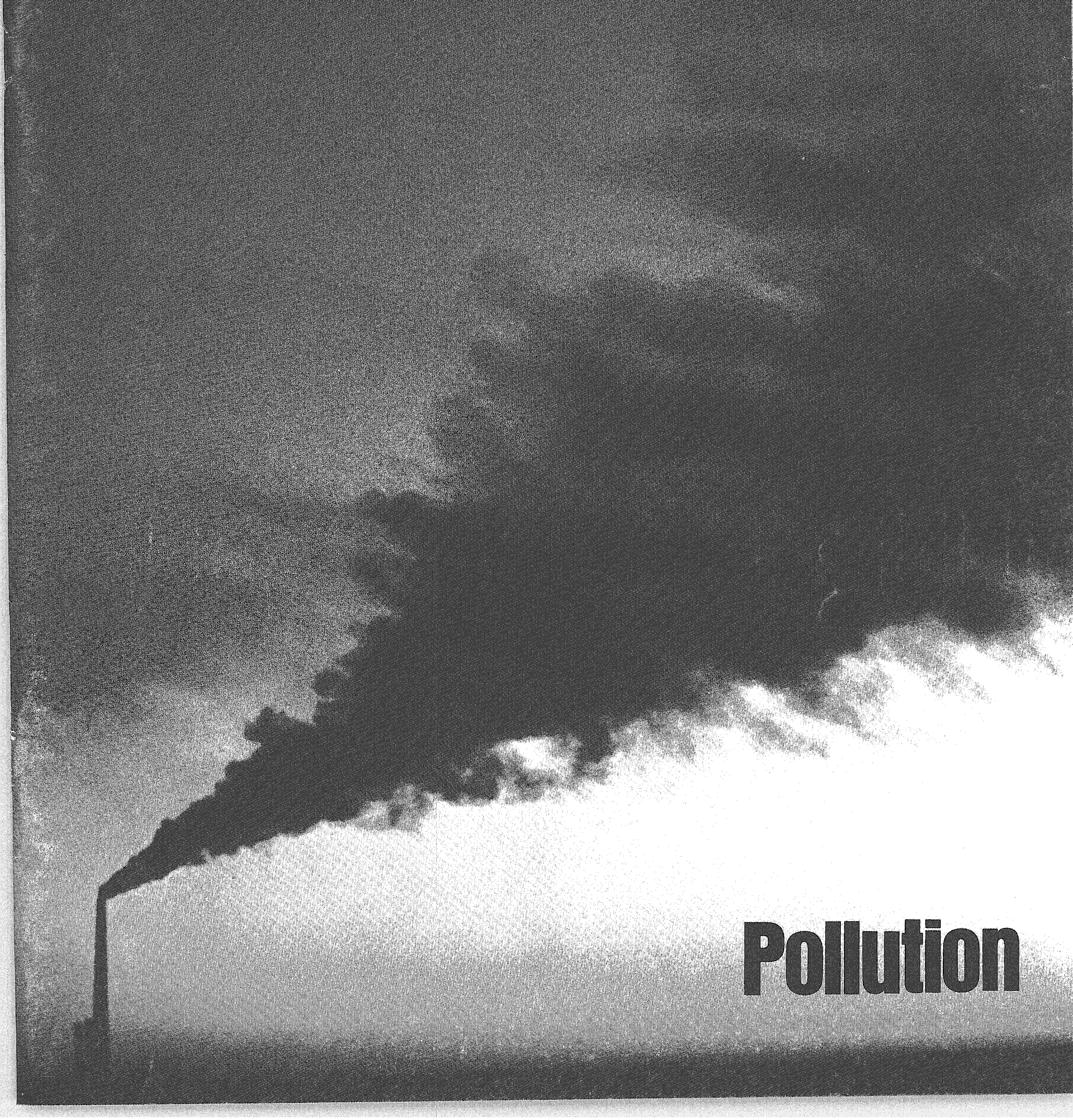
They will synchronize dozens of real-time systems whose slightest move affects the performance of every other system. The frontiers of manufacturing technology have been thrust outward. Old ideas have been questioned, new ones probed. Some ideas are now on production lines. Others are still flickers of light in an imagination.

All offer opportunities for you to seek, to grow, and to accomplish.

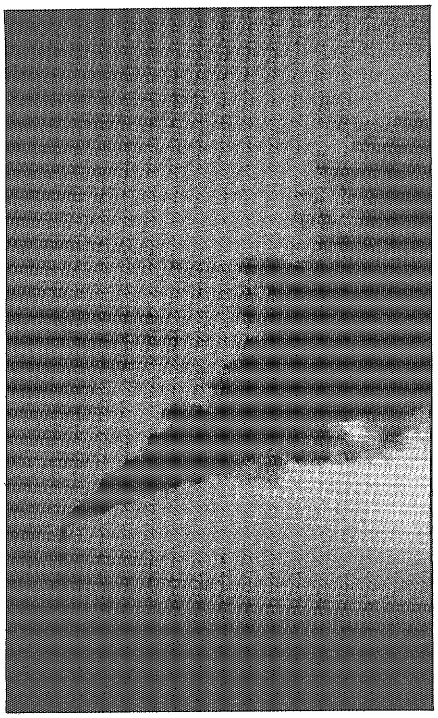
If you can dream it, you can do it.

minnesota TECHNOLOG

Winter 2, 1984



Pollution



Smoke belches from a smokestack located in Sudbury, Ontario. The continent's single greatest source of SO_2 emissions, the nickel-smelting complex has reduced emissions by 70 percent since 1969. This beautiful and yet ominous photograph was taken by Dr. F. Fanaki of the Atmospheric Environment Service, Downsview, Ontario.

Winter 2, 1984

minnesota
TECHNOLOG

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Vol. 64, No. 4

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Departments:

Log Staff:

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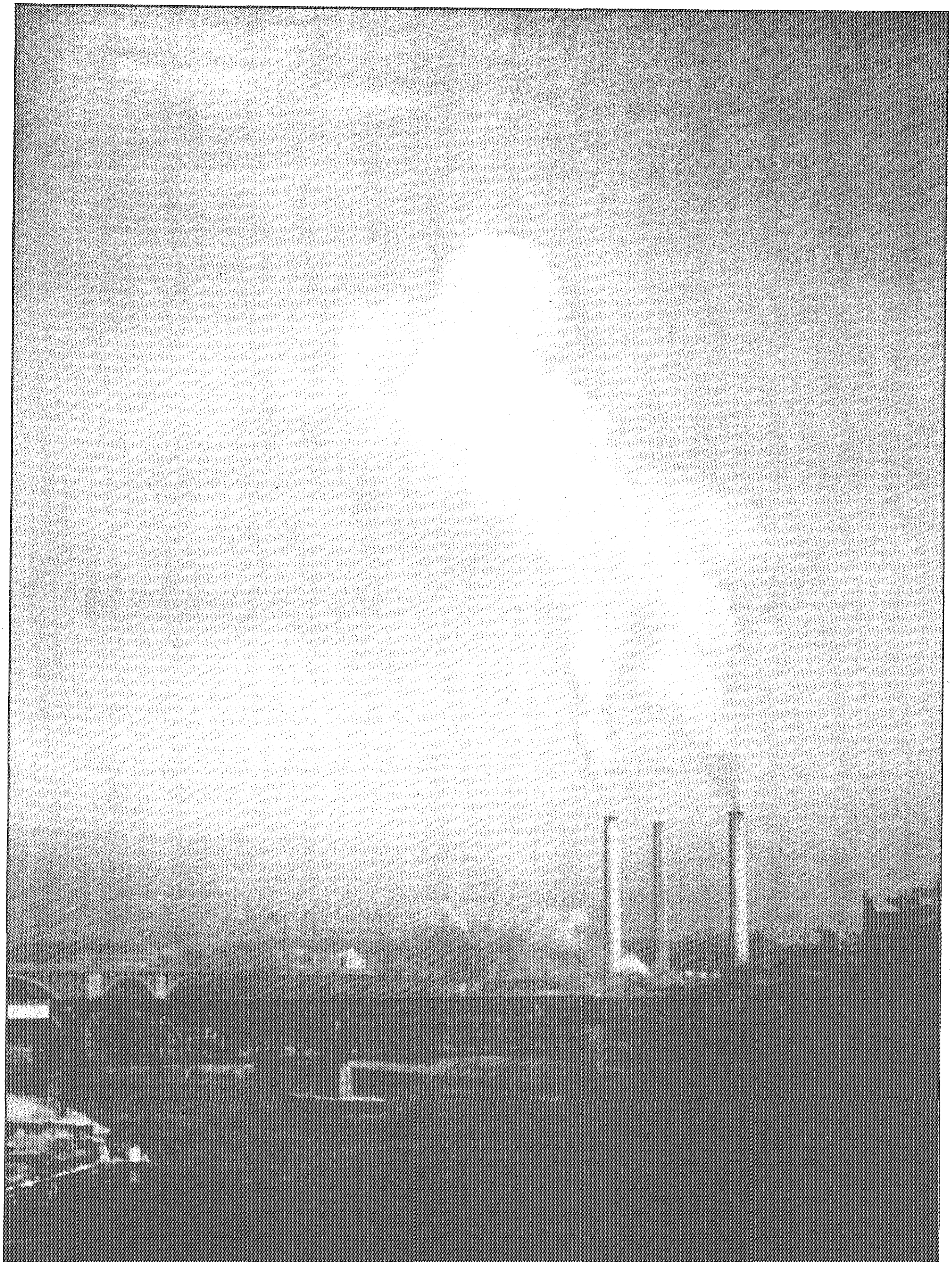


Editor's Log

Pollution: Past and Present

From an ecological point of view, 15 years is not a long time. Yet tremendous progress in cleaning the environment has been made in this time span. In the late sixties and early seventies, untreated sewage was dumped into lakes, rivers were graveyards of dead fish, and the air in many cities was fit to be seen, not breathed. Stories are told about a small town fire department which was called by alarmed citizens who thought clouds of black smokestack effluent were actually the result of fires burning out of control. Drivers in Los Angeles pulled to the side of the road because their watering eyes prevented them from seeing. Today smog alerts are far less common, and fish can again be found in many previously desolate lakes. The list of successes is extensive and includes such impressive victories as Tokyo's smog problem and the once filthy Thames River. In the United States alone billions of dollars are spent annually on the environment.

But the pollution problem isn't ready to be confined to history books yet. Bigger and uglier problems have begun to make their presence known and are being wrestled with across the country. Some of these problems, such as acid rain, are not limited to a particular city, state, or country and therefore require international cooperation. Depletion of the ozone layer and the greenhouse effect are problems which will test man's ability to formulate and enforce international environmental treaties. Niagara's Love Canal has proven to be only the tip of a hazardous waste iceberg temporarily buried under a thin layer of topsoil in many places across the country. And on top of these chemical and ecological problems has been dumped political scandal. The debacle of the Environmental Protection Agency during 1983 can only erode favorable public opinion toward the spending of billions of dollars on the environment.

The pro-environmental mood of the country will be tested more in the future as clean up costs are expected to climb. *U.S. News & World Report* estimates that it will be necessary to spend $690 billion in the 1980s to achieve and maintain a clean environment. Last year $50 billion—an amount that some have argued could fuel inflation—was spent in the United States to reduce pollution. This cost breaks down to $220 per man, woman, and child. Some polluting factories will also be forced to close because they cannot afford expensive pollution control equipment, resulting in the loss of jobs. The question of how much should be spent on cleaning the environment is now being asked in Washington, D.C., and elsewhere. When faced with pollution or lost jobs, many people will choose pollution, especially if the bulk of the effects will not be felt for years to come.

The engineer's challenge is to advance technology so that these questions need not be asked. There exists room for immense improvements in pollution control technology. New economical and efficient scrubber systems for coal-powered plants are needed for a broader utilization of relatively inexpensive domestic coal and lower energy costs without the disadvantage of increased rain acidity. Of course, many more traditional problems, such as the safe storage of radioactive waste, must also be dealt with in the coming years. In the end, the voting populace and politicians will decide which way the scales of pollution versus costs and lost jobs will tilt, but the engineer will be able to bias the scales in such a way that only a small cost and jobs sacrifice will be necessary to effectively counteract the pollution problem.

Hopefully we will continue our drive to clean up our air and to make our water safe for drinking, swimming, and wildlife. The investment would surely be appreciated by our children, for even though the cost of a cleaner environment is high, the cost of pollution is higher.

Alan Hauser

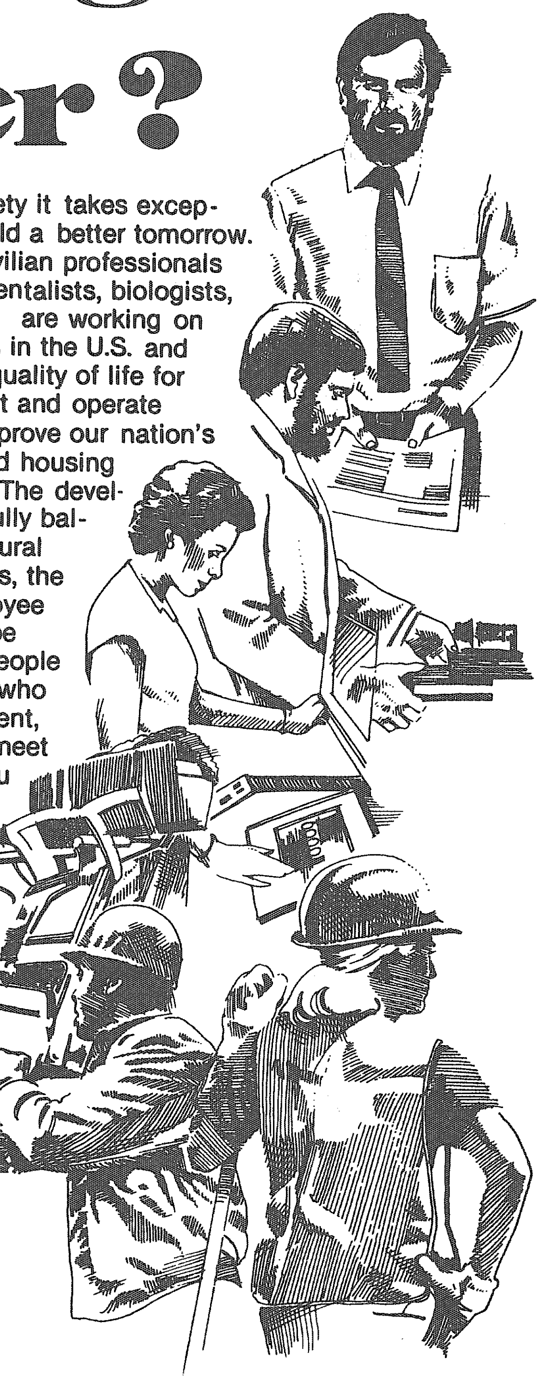
Alan Hauser

Editor

US Army Corps
of Engineers

Building your career?

In today's complex technological society it takes exceptional planning and engineering to build a better tomorrow. The Corps of Engineers' dedicated civilian professionals . . . engineers, planners and environmentalists, biologists, economists, landscape architects . . . are working on a variety of jobs in a variety of places in the U.S. and overseas to improve and protect the quality of life for all citizens. We plan, design, construct and operate water resource projects, build and improve our nation's ports and harbors, build hospitals and housing projects for the Defense Department. The development of the projects must be carefully balanced with the preservation of our natural environment. The balance is precarious, the challenge extreme. As a civilian employee with the Corps of Engineers you will be joining an organization that believes people are our most important asset. People who respond to a challenge with commitment, skill and innovation. You can help us meet the challenge. Ask us and we'll tell you more about a career with the Corps of Engineers.



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Log Ledger

By Scott Dacko

- **Editor and Business Manager Positions Open**

Want a chance to meet interesting people, develop your management skills, improve your writing, and be responsible for the production of a college magazine? The Institute of Technology Board of Publications is now accepting applications for the 1984-85 *Minnesota Technolog* editor and business manager positions. If you are interested, come into Room #2, Mechanical Engineering, and talk to this year's editor and business manager about the responsibilities and rewards of the jobs. All applicants must be full-time University of Minnesota students. Preference will be given to I.T. students. The chosen applicant will receive training by working with this year's staff during spring quarter. This year's salaries were as follows: editor—$1,800, business manager—$900. All resumes and writing samples must be submitted by February 24, 1984. For more information, call 373-3298.

- **New EE/CSci Building Favored**

The Board of Regents at the University of Minnesota voted 8-4 at a November meeting to list a new electrical engineering/computer science building as the University's highest building priority for the 1984 Minnesota legislative requests. Previously the EE/CSci building was second priority, with a new animal science building listed as first. The University will request $3.4 million to commission working drawings for the building, which will have a total projected cost of $56.6 million. University of Minnesota President C. Peter Magrath cited several reasons for the change in priorities, including the fact that Minnesota is internationally known for its electrical engineering and computer science industries.

- **Landlords in Space**

In the 1990s, if you want to do astronomical research, make infrared maps of the earth, or manufacture pharmaceuticals or special alloys in space, you may be renting space on the Fairchild Leasecraft, a low-orbit satellite-manufacturing facility, a group of engineers told attendants of a recent American Society of Mechanical Engineers (A.S.M.E.) annual meeting in Boston. NASA and Fairchild signed an agreement in August 1983 for the research and development of the Leasecraft platform for commercial operations. Rent will not be cheap, costing somewhere between $1 million and $4 million per month, depending on the amount of space and power required and whether your module can share facilities with other renters.

I.T.'s Bulletin Board

Examples of astronautical applications include an advanced x-ray astrophysics facility and a shuttle infrared telescope facility. Examples of manufacturing include the preparation of alloys and growing crystals, in addition to the manufacturing of pharmaceuticals difficult to prepare on earth.

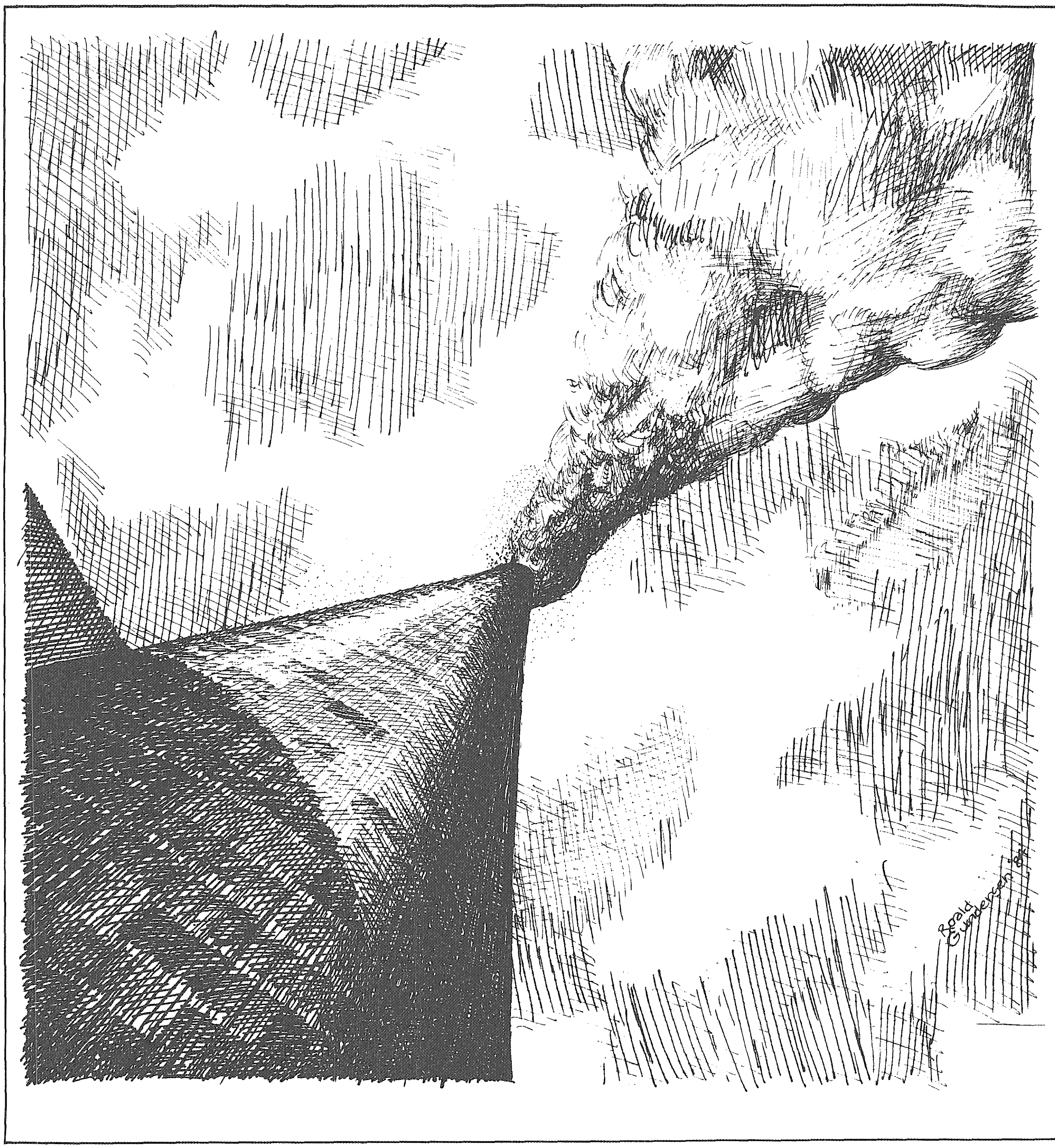
- **Dry Ice Preserves Food**

Liquid and crystallized carbon dioxide can economically preserve food shipped by rail, according to FGE Cars, Inc. of Virginia. The company believes that nonmechanical, cryogenically cooled freight cars can economically replace the aging fleet of mechanically refrigerated cars. The use of cryogenic cooling to transport frozen food not only eliminates the expensive maintenance and upkeep of mechanical cars but also eliminates the cost of actually running the refrigeration equipment. A converted 100 ton mechanical car carrying frozen citrus concentrates from Florida to California used less than three tons of liquid carbon dioxide, which is available in quantity for $50 per ton.

- **Shoes Better Than Bare Feet**

Two professors in the Department of Engineering Science and Mechanics at Iowa State University have concluded that going barefoot is bad for you. Their results were presented at an annual A.S.M.E. meeting in Boston. (Since that time, both have taken a great many steps in cushioning the blow these results have had on the soles of a great many shocked Iowans.)

Continued on page 32



Rain, Rain, Go Away

By Renee Kostner

We are usually unaware of its presence. We do not see it or smell it in the air we breathe, yet scientists believe it is damaging the soil and water around us. In past years little was heard about acid rain although acidic precipitation was linked with coal combustion as far back as 1911 in a British study. In the 1980s, however, acid rain has leaped into the headlines. Currently, at least four professors at the University of Minnesota are doing research involving acid rain.

Acidity is measured on a logarithmic pH scale, with zero being highly acidic and 14 being highly alkaline. Natural precipitation, usually falls between 5.0 and 5.6 according to a scale by the Environmental Protection Agency (EPA) published in the "Minneapolis Star & Tribune." Most fish will die if a lake's pH falls much below 5.0.

Acid rain is actually only one form of acid deposition, the transfer of acid from the atmosphere to the Earth's surface. Acid rainfall is the best known because it is the easiest to measure. This is what got people interested in the phenomenon, says Professor Peter McMurry of the University of Minnesota's Mechanical Engineering Department. However, acidic aerosol particles can be deposited to the Earth's surface on a clear day through a process called "dry deposition." Dry deposition depends on an area's surface, vegetation, and meteorology. "Dry deposition, under certain circumstances, contributes a substantial fraction of the acid flux to the surface," says McMurry, who is interested in studying the formation of acid-containing particles and airborne particles.

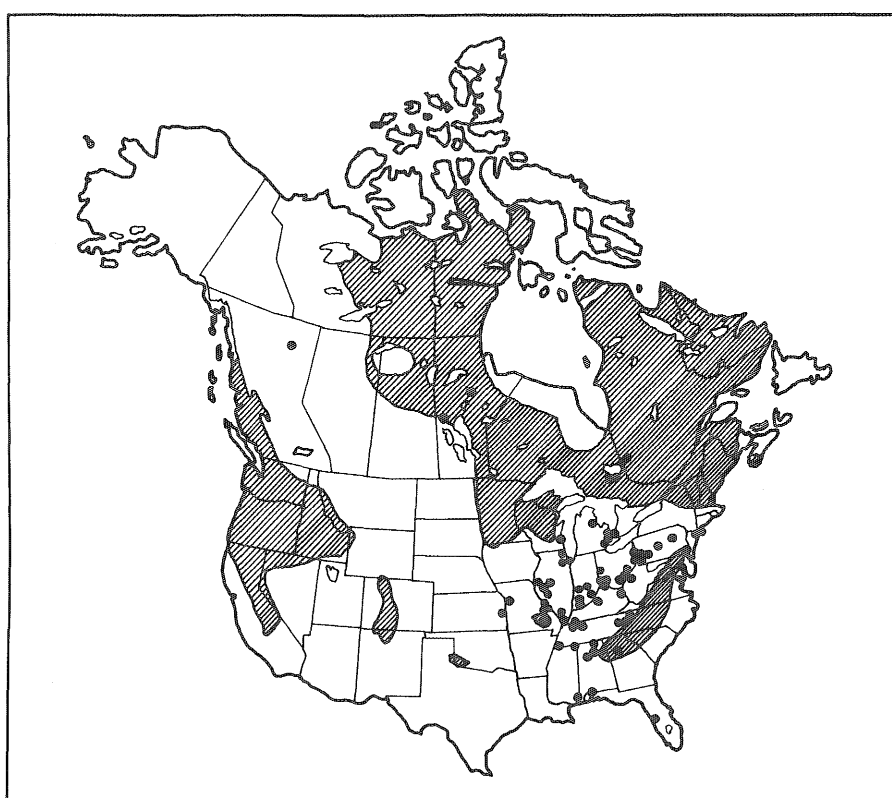
The sulfate and nitrate species are believed to be the causes of the flux of acid to the Earth's surface. "As a generalization, the most important national source of sulfates would be the emissions from power plants, especially coal-fired power plants," McMurry says. Nitrate species such as nitric acid are initially emitted as nitric oxide. An important source of nitric oxide is automobile emissions, McMurry continued. Although power plants are another source of nitric oxide, automobiles are important because they are more widely distributed, and the material that is emitted is likely to be deposited on the ground.

In addition to rainfall and dry deposition, snowfall is another process by which acid reaches ground and water surfaces. Accumulation of acidity in the form of snow will occur throughout the winter, and when spring melting occurs, a heavy dose of acid may be added to watersheds.

Some ground water systems have a greater capacity to buffer the effects of acid than others. The buffering capacity depends on how much acid the water system can take without having a significant drop in pH. Some systems, such as the Boundary Waters Canoe Area in northeastern Minnesota, have a very poor buffering capacity. Therefore, these areas are more sensitive to acid deposition. Areas with large concentrations of limestone in the water can have a much higher buffering capacity, which means they can be exposed to large amounts of acid without exhibiting a negative effect. Adding limestone to lakes is one technique that has been proposed for controlling the pH of lakes, McMurry says. But the liming of lakes is itself controversial. Opponents say that the process is too expensive, while proponents declare that it will be cheaper than controlling emissions. It has also been argued that control should logically be at the source rather than at the receptor, since acid rain often originates in another state or country.

Patrick Brezonik, University of Minnesota professor of Environmental Chemistry and Water Quality, is working on three different projects that he hopes will result in possible controls. One project is a long term study in northern Wisconsin. The objective is to acidify a lake and evaluate the effects under controlled circumstances. The plan is to divide the lake into two parts and to add sulfuric acid to one half and then monitor the plants, the fish, and the ecosystem. The project, which started in the summer of 1983 on Little Rock Lake in Wisconsin, will probably last for eight to ten years. The lake being studied is a soft water lake, which

Areas of North America most sensitive to acid rain. The dots indicate areas having the heaviest concentration of SO_2 emissions.



means that it does not have a large buffering capacity.

In the past, lakes' buffering capacities have not been studied. Brezonik's second project, which began only two years ago, will look at the role lake sediments play in neutralizing acid put in the lake by the atmosphere. His third project involves evaluating previously developed sensitivity models. These are empirical models based on observation and data instead of theory. He is studying the extent to which these models can be applied to the Midwest using data from upper Michigan, northern Wisconsin, and northern Minnesota. His research is primarily funded by the EPA, and will provide information to the regulatory agencies for possible controls.

Environmental Chemistry and Geochemical Cycles Professor Steven Eisenreich's research is funded by federal agencies such as the EPA and the National Oceanic and Atmospheric Administration (NOAA). Eisenreich was the first to establish the occurrence of acid rain in Minnesota. He does not, however, directly study acid rain; his emphasis is on how pollution affects the atmosphere. In one area of his research, he is trying to document the transportation of toxic organics in and around Lake Superior. He views Lake Superior as a large beaker suitable for the study of how the pollutants get there and how they are dispersed.

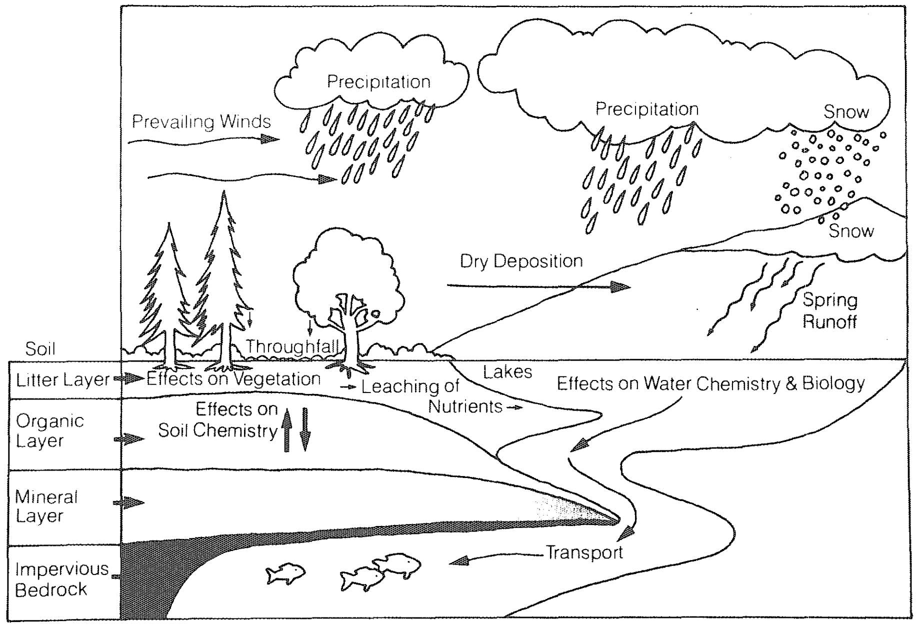


Illustration of terrestrial and lake effects of acid deposition.

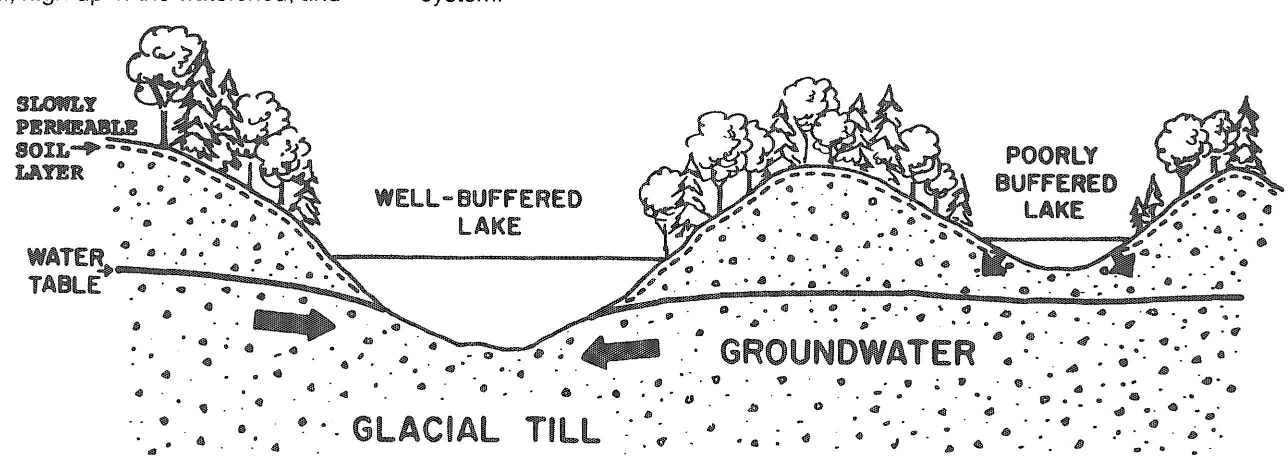
Not only midwestern lakes are being studied. Professor Eville Gorham of Ecology and Behavior Biology was one of the first to study acid rain when he did research in the Lake district of England in the 1950s. He recently did an analysis of all of the states east of the Mississippi. He says there are three factors controlling the chemistry of rain: air pollution, soil constituents such as ammonium and calcium, and sea spray. Gorham definitely believes that acid rain is a problem and steps should be taken to control it. "I think there should be marked reductions in emissions of sulfur dioxides," he says. The major emitters are the midwestern states while the major damage is to New England. Besides cleaning up the coal plants in the Midwest, clean up should be done locally in New England in such places as New York state.

Eisenreich and McMurry are not as outspoken about what should be

Buffering

According to a report being prepared by the Minnesota Pollution Control Agency,[1] certain universal characteristics are often associated with lakes which are sensitive to acid rain. Sensitive lakes are generally small, high up in the watershed, and surrounded by steep slopes. They typically have no inlets but do have soils in their watersheds which quickly release rain water to the lake. They are usually situated above the regional water table and receive little or no inflow from the local flow system.

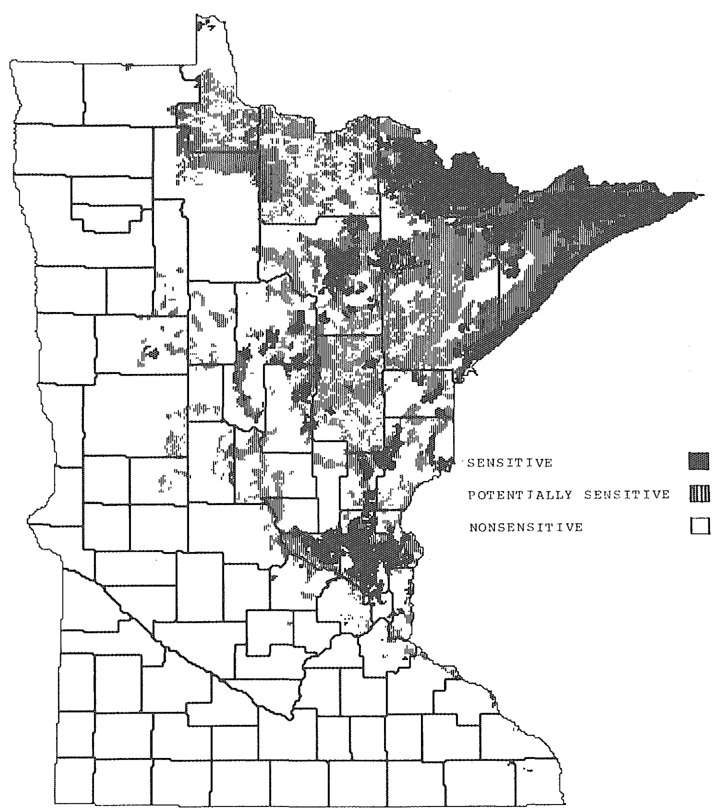
1. Twaroski, Thornton, and Heiskary; *Aquatic, Terrestrial and Peatland Ecosystems in Minnesota Considered Sensitive or Potentially Sensitive to Acid Deposition,* Minnesota Pollution Control Agency, 1983.



done about acid rain. Rather they see their role as that of information providers. Eisenreich says his research "will provide a fundamental base of information to allow proper management decisions to be made on the best use of the peatlands."

"It's the job of the scientist to educate, to do a good job of determining . . . the scientific truths and educating the public as to what the issues are," McMurry says. And, ultimately, the public will have to pay for any source control, he says.

Some scientists believe enough is known about acid pollution to begin trying to control it, although they continue studying it for its long-term effects. Since acid pollution does not recognize state or national boundaries, steps must be taken on a national and international basis to control it. As it is now, Canada is also feeling the effects of our acid pollution and says the United States is not doing enough to control the pollutants. In all likelihood this debate will continue for quite some time because the problem of acid rain will not go away by itself. ■

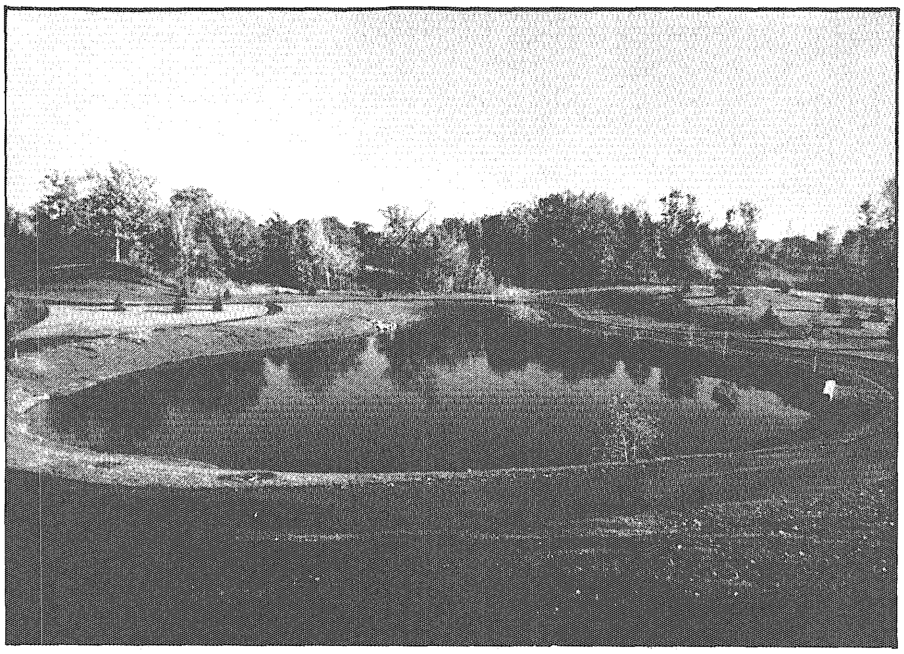


Areas in Minnesota containing sensitive or potentially sensitive aquatic and terrestrial ecosystems.

Courtesy of the Minnesota Pollution Control Agency

Lake Restoration and Management

Ecology and Engineering United



A storm water holding basin.

By Mary Wilkosz

"Lake resources are irreplaceable. Once they are gone, they are gone. They also seem to have a threshold beyond which it is no longer possible to technologically or economically return them to a productive quality."

Robert J. Johnson, President, North American Lake Management Society, from Lake Restoration, Protection and Management, *USEPA, 1983*

During the summer of 1980, the Metropolitan Council conducted a water quality study of 60 lakes in the seven county metropolitan area. They concluded, "the Metropolitan Area lakes, with a few possible exceptions, are eutrophic." "Cultural eutrophication" is the process in which a body of water is over-fertilized (having an excessive amount of nutrients) due to human activities. The natural eutrophication of a lake in areas unaffected by human beings can take hundreds of years to occur, whereas cultural eutrophication can take as few as four or five years, as it did in Seattle's Lake Washington. Agriculture, industry, municipal and domestic waste collectively contribute to this process. Several ecological changes occur as a lake's chemical and biological systems for coping with the increased nutrient influx are impaired, causing the lake to age prematurely.

The high nutrient concentration, particularly the phosphorus concentration, found in eutrophic lakes greatly surpasses the nutrient requirements of the phytoplankton (small, floating aquatic plants). A copious nutrient supply causes the phytoplankton, and in particular the blue-green algae, to proliferate in the warm, shallow depths of a lake, the "epilimnion." Blue-green algae are more abundant under these conditions because they can better adapt, and thus out-compete other types of phytoplankton. The large algal populations cause several consequential changes in a lake's ecology and appearance—changes generally considered by the public to deteriorate the water's aesthetic and recreational quality.

The blue-green algae give the normally blue to green tinted, clear water a greenish-yellow, scummy appearance. Meanwhile, the deep, cold, denser lake water, the "hypolimnion," receives falling organic detritus, primarily composed of dead algae and external organic material from the overlying epilimnetic waters. As this organic material decomposes in the hypolimnion, the dissolved oxygen concentration is depleted, sometimes completely. In turn, game fish such as trout or bass which require cold, oxygenated water to survive, are slowly replaced by bottom-feeding fish such as carp and bullheads, which can inhabit waters of low oxygen concentration.

Born in the 1950s, lake restoration and management is a new concept which did not really catch on until the 1970s. Lake restoration and management practices are designed to restore and improve the water quality of eutrophic (or acidified) lakes and to protect and preserve our water resources for present and future generations. The goal of most lake restoration projects is to reduce the external nutrient influx to the affected lake. If all goes well the lake should assume an "oligotrophic" appearance. Oligotrophic lakes have low nutrient concentrations and cold, clear, oxygenated water extending into the hypolimnion. The low nutrient concentrations restrain algal productivity, keeping the lake relatively transparent.

Of all the nutrients contributing to cultural eutrophication, phosphorus is far and away the most important. It is generally the "limiting nutrient" (the element in least supply) in natural fresh-water systems. Algal populations are much less abundant and green algae generally dominate over blue-green algae in oligotrophic lakes lacking an external source of phosphorus. Green algae out-compete blue-green algae by better utilizing other nutrients when phosphorus concentration is low.

Phosphorus is externally supplied through sewage effluents to water bodies in or near human populated areas. As the phosphorus concentration increases, so does algal productivity, and the lake's sediment nutrient reservoir is replenished also. If eutrophication sets in as a result of the enhanced algal productivity, the hypolimnion could become anoxic, and a reducing environment might be created. The reduced forms of phosphorus and other nutrients, unlike the oxidized species, easily escape from the lake bottom sediments and then migrate back into the epilimnion where the recycled nutrients are once again utilized by the algae. Once nutrient mobilization begins, external nutrient source reduction alone could fail to restore the lake to its previous oligotrophic appearance.

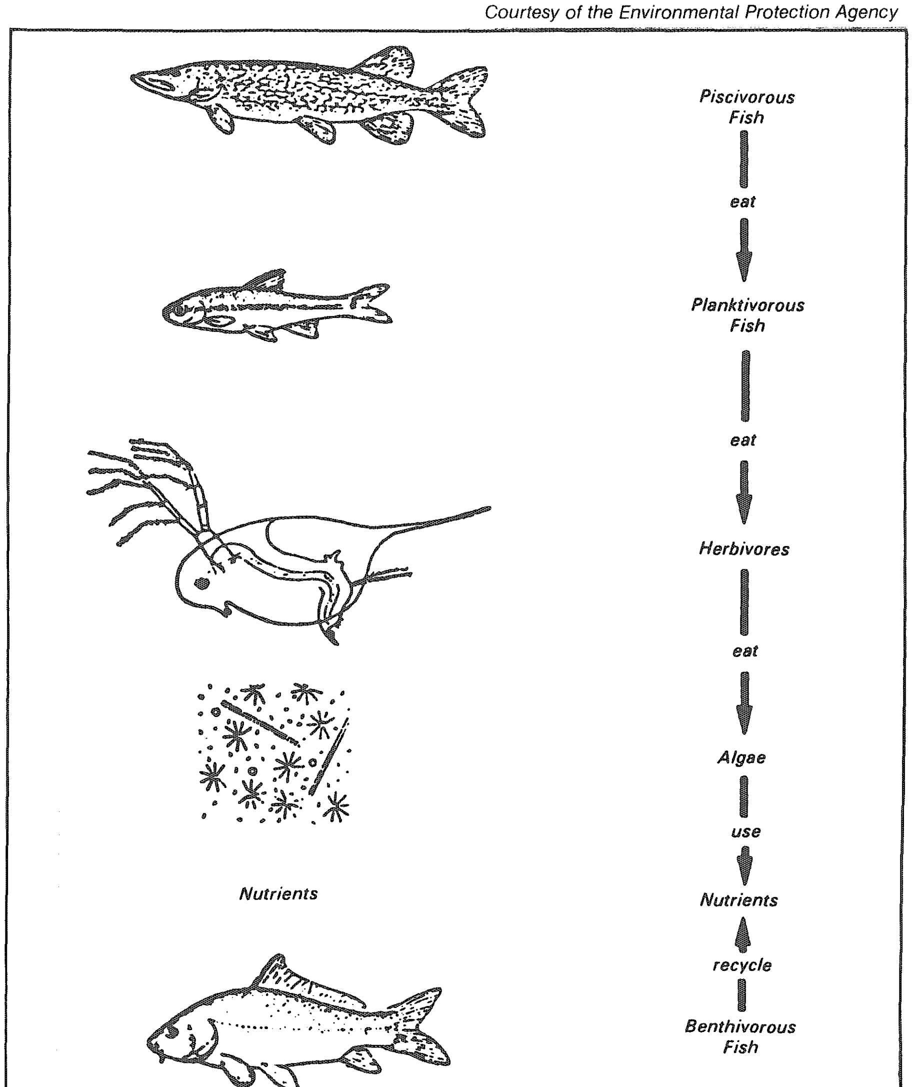
Unless alternatives are found to our current waste and wastewater treatment practices, eutrophication could become much more prevalent. Some lakes will die for lack of money or interest in restoring them. According to Joel Schilling, principal of Schilling Environmental Consultants and secretary of the North American Lake Management Society (NALMS), economics are likely to be the biggest obstacle facing future lake restoration projects. Says Schilling, "...there will be nationally, and I think in Minnesota as well, lakes that we'll simply write off.... We won't have the money to restore them." If the public concern is great enough, however, funds could be generated to plan and implement lake restoration and management projects.

Lake restoration techniques to date have primarily been attempted through engineering. A new ecological approach, however, termed biomanipulation, is just beginning to earn the attention of scientists and engineers alike. A major advantage of biomanipulation over engineered lake-restoration techniques is cost. For instance, rotenone, a common fish toxin, used to kill rough fish (carp, catfish, and bullheads), is often used to biomanipulate a lake. Rotenone costs about $10 per acre-foot to apply. In comparison, the average cost of an engineered lake-restoration project ranges between $500 and $1,000 per surface area according to Schilling. This varies with the restoration method chosen, however. Once a lake has been restored, the Department of Natural Resources (DNR) will restock it with game fish free of charge, providing the lake has a public access.

Both biomanipulation and engineered restoration approaches have the same end—to reduce abundant, undesirable algal populations—but it is the means to the end which characterizes their distinction. The engineered projects are designed to restore the lake by reducing nutrient inputs from external sources or from the anoxic sediments. Biomanipulation, on the other hand, utilizes the biological interactions within the lake itself to reduce nuisance algae (particularly

The aquatic food chain (not to scale).

Courtesy of the Environmental Protection Agency



blue-green algae), creating an overall increase in lake transparency.

Dr. Joseph Shapiro, a professor at the University of Minnesota Limnological Research Center, has studied many techniques of biomanipulation and is one of its leading advocates. A 1983 Environmental Protection Agency publication, "Experiments and Experiences in Biomanipulation: Studies of Biological Ways to Reduce Algal Abundance and Eliminate Blue-Greens," authored by Shapiro and others, presents some biomanipulation techniques.

The first technique is designed to indirectly reduce the blue-green algae population by eliminating bottom-feeding fish. Bottom-feeders obtain phosphorus, nitrogen and other nutrients while feeding and then excrete these nutrients back into the water. Their excrement dissolves into nutrient forms easily assimilated by phytoplankton, increasing algal productivity. In the case of Lake Marion, located in south central Minnesota, fish excrement accounted for half of the total phosphorus input. Additionally, the bottom-feeders agitate the water and sediments as they feed, stimulating nutrient mobility. Rotenone was used to eliminate the bottom-feeding fish to curb these effects, and game fish were then restocked.

Replacing rough fish with game fish is one way to indirectly manipulate the algae population, but there are direct biomanipulation options available too. Lowering pH by adding carbon dioxide (CO_2) or hydrochloric acid (HC1), and nitrogen stimulates a shift from blue-green to green algae. Green algae are generally preferred to blue-green algae. Artificially circulating a eutrophic lake may have a similar effect since deep, rapid mixing usually reintroduces CO_2 and other nutrients into the "photolytic zone," the upper portion of a lake in which algae live and photosynthesize.

Also, blue-green algae may be indirectly reduced by manipulating the populations of organisms occupying higher trophic levels of the aquatic food chain. This theory follows a simple line of logic based on a few predator-prey relationships. For example, phytoplankton occupy the lowest level of the food chain, followed by herbivorous (plant-eating) zooplankton, which occupy the second trophic level. The zooplankton are consumed by planktivorous (plankton-eating) fish which are in turn eaten by piscivorous (fish-eating) fish. If the planktivorous fish population is decreased, a proportional increase of large herbivorous zooplankton will occur due to a decline in predation. The increased zooplankton population, requiring a larger food supply, grazes more heavily on the blue-green algae. As the algae population decreases, the lake's transparency increases. If this happens, the project is successful.

Biomanipulation, like the science of lake restoration itself, is still in its infancy. Much is yet to be learned, but some people, like Shapiro and Schilling, envision a bright future for biomanipulation when used alone or in combination with engineered lake-restoration measures.

"...[Ecological and engineered restoration techniques] are coming together if you have someone on the other end that can force the engineer to reorient his way of thinking..." said Schilling.

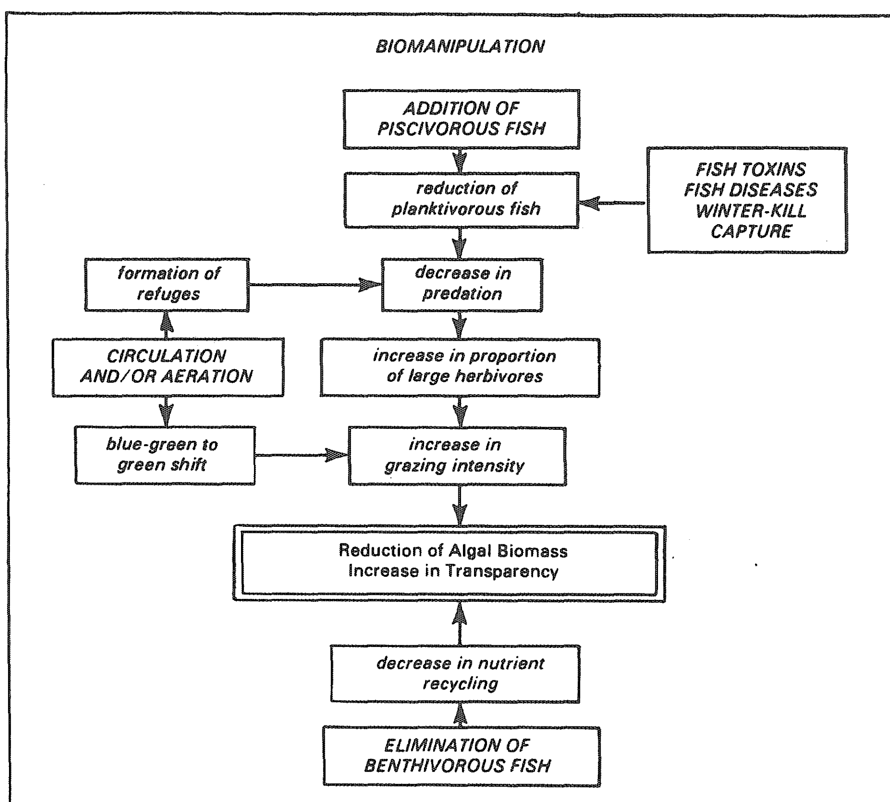
Steve Heiskary, a biologist at the Minnesota Pollution Control Agency (MPCA), also holds a positive outlook on the future of biomanipulation when used with other restoration measures, but Heiskary added a cautious remark to his praise.

"If you're still getting a large influx of nutrients into that [water] system, it seems to me that it [biomanipulation] would be unlikely to generate a great deal of improvement over an extended period of time."

Until more biomanipulation experiments are conducted, until more data is produced, the ecological lake restoration measures shall likely be overshadowed by the engineered restoration techniques. Several lake restoration projects in Minnesota have been undertaken using the latter approach.

The Long Lake chain of lakes project is Minnesota's, and possibly one of the nation's, most ambitious and expensive lake restoration

Some aspects of biomanipulation.



pursuits. This chain of lakes is located in the northern Twin Cities' suburbs of New Brighton, Roseville, and Fridley. The restoration project relied on storm sewer diversion, artificial sedimentation basins, erosion control measures, dredging and a new outlet structure to curb the nutrient influx rate. The total cost for the Long Lake project was just over $3 million.

The restoration measures used in the Long Lake project were engineered to limit the water's fertility. This can be accomplished by slowing the rate of nutrient inputs to the system and/or speeding the rate of outputs away from the system.

Lake Josephine, one of several lakes included in the Long Lake project, had its nutrient inputs delayed and decreased by diverting the lake's stormwater into Little Lake Josephine and to an adjacent wetland. Stormsewer diversion is a common restoration technique designed to "...slow and spread the flow [of nutrients], and allow it to come in contact with as much of the vegetation and soil as possible," said Heiskary. This allows the plants to take up the nutrients while simultaneously allowing the sediment to settle before the stormwater enters the lake.

The several artificial sedimentation basins constructed for the Long Lake project are another example of how nutrient inputs may be retarded. Sediment control is important, not only because it is a physical pollutant itself, but because sediments also serve as nutrient transport agents. Sediment influx to the lake was also slowed through erosion control measures.

"One of the most serious nonpoint source problems we have is stream bed and stream bank erosion," according to Schilling, who worked for the MPCA during the early years of the Long Lake project. This problem was remedied by using rock gabions or grouted riprap on drainageways which are tributaries to Little Johanna, Valentine, and Pike lakes. New building codes also require large industry, office buildings, department stores and the like to temporarily store part of their wastewater on-site. This is an effective means of controlling the rate of water flow into the lakes.

Other engineered methods designed to limit fertility of an aquatic system include, but are not limited to, wastewater treatment plants, product modification (i.e., removing phosphorus from detergents), clustering development around natural drainage systems, and street sweeping.

Fertility limitation of the Long Lake chain of lakes project was attempted not only by slowing the nutrient inputs to the system but by hastening the outputs as well. Dredging the Long Lake deltas of sediments was the method chosen by the MPCA to accomplish this task. Dredging reduces nutrient loading by removing nutrient-rich sediments to uncover a less fertile layer and by preventing internal nutrient recycling by physically deepening the lake.

Several other lake restoration methods designed to speed the nutrient outputs of the system exist in addition to dredging. The following methods are a few presented by the Wisconsin Department of Natural

Continued on page 30

Hazardous Waste and the University of Minnesota

By Jim Lundy

By nearly any measure at all, the problem of the disposal of hazardous waste is a highly unglamorous topic. Yet to the extent that we in the United States have witnessed high technology research and continued industrialization, it is a growing problem from which we cannot turn. Indeed, each year since 1945 has seen a 10 percent increase in hazardous waste production in the United States, until now about 80 million pounds of it are generated annually. The U.S. Environmental Protection Agency (EPA) estimates that only 10 percent of this total is disposed of in an environmentally sound manner. These practices clearly must not continue; safe disposal of hazardous wastes is imperative.

Such problems are the concern of the Department of Environmental Health and Safety (EHS) at the University of Minnesota. It is obvious that the University, a large producer of hazardous waste, can hardly claim any sort of amnesty under ivory tower pretensions. For this reason, EHS has developed programs for the safe disposal of University-generated biohazardous infectious, chemical, and radioactive hazardous wastes.

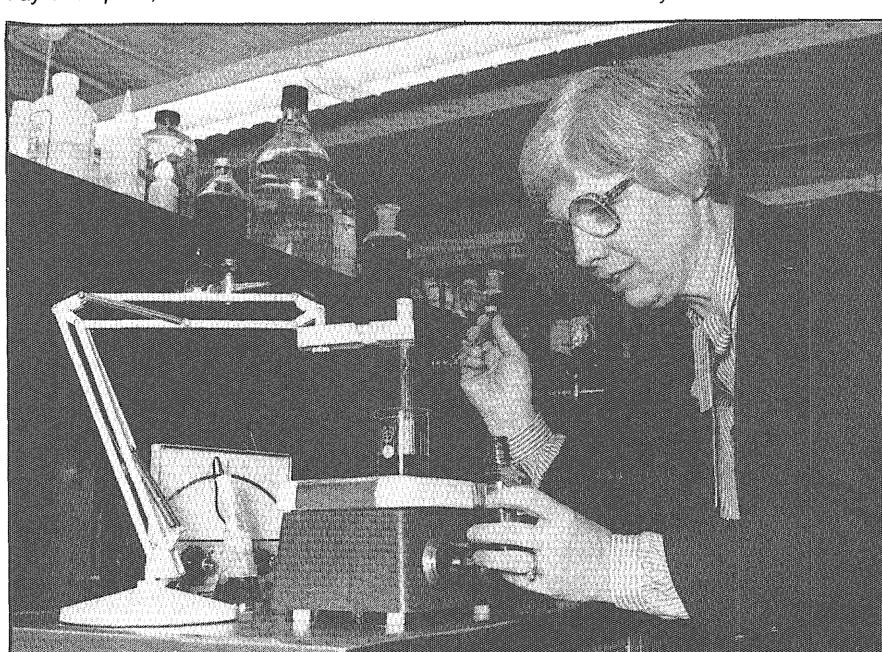
Biohazardous infectious waste is any waste that originates from the treatment of a patient with an infectious disease, or any material generated in a research laboratory which presents a potential hazard to the health of the community. Such waste, if improperly handled, can result in outbreaks of diseases such as hepatitis type B, tuberculosis, salmonella, or AIDS, according to James Lauer, biosafety officer at EHS. Though generated in smaller quantities than other types of waste, only a speck of an infectious agent on a technician's hand could cause an outbreak of disease. As upwards of 1 million pounds of infectious waste a year is produced at the University hospitals, proper disposal becomes important.

Lauer said that certain types of infectious waste, generally those articles contaminated in laboratory work (cultures, glassware, etc.), can be autoclaved. In this process, the article is sterilized by pressurized steam at 121°C, which kills all the microorganisms present. The article then poses no further risk to the community, and can be disposed of as ordinary solid waste.

Wastes generated in hospital rooms (gauze, paper, etc.) usually cannot be autoclaved and are instead placed in plastic-lined paper bags clearly labeled as biohazardous infectious waste. These are moved to the loading dock at the hospital and are eventually trucked to Eden Prairie, where they are burned in an incinerator. The incineration of the wastes presents no health threat as the infectious organisms are killed when they are burned.

Disposal of infectious waste costs the University roughly $100,000 per year, Lauer said. This relatively low cost is due in part to a redefinition of infectious waste put into effect about two years ago. This redefinition,

Fay Thompson, assistant director of Environmental Health and Safety.



according to Lauer, reduced the total volume of waste handled by a factor on the order of one-third to one-half, saving the University "something like $60,000 to $90,000 a year." Other factors contributing to the low cost of this program include the small record-keeping and paperwork load, and the fact that no further responsibility need be taken by EHS once the waste has been destroyed by incineration.

In contrast, EHS must remain accountable to the public regarding chemical wastes virtually forever. Fay Thompson, assistant director of EHS, defined hazardous chemical waste as any material that is unacceptable in terms of flammability, corrosivity, reactivity or toxicity. Despite the huge variety of wastes generated, most are classified as hazardous chemical wastes only because they have a flashpoint below 140° F and are therefore flammable. Thompson pointed out that "not everything is a carcinogen. Some things are hazardous only because they burn readily. The toxicity of these [wastes] is generally fairly low... there are lots of [wastes] in which toxicity is not the problem, but they *do* burn. Flammability *is* a problem."

Such problems are dealt with by the costly ($200,000 to $300,000 per year) EHS hazardous chemical waste program. Laboratory workers must bottle, box and clearly label all generated hazardous wastes, which are collected once a week by a specialist from the Physical Plant. Some materials may be reusable and are made available free of charge to other labs (a relatively new practice which saves the University about $25,000 to $30,000 per year in disposal costs). The pourable, flammable (nonreactive) wastes are poured into 55 gallon drums and marketed elsewhere as a fuel supplement. Nonpourable wastes are placed in other drums, bottles intact, such that about 40 gallons of drum volume is occupied by an absorbent packing material (vermiculite) to guard against leakage. After the drum is sealed, it is taken to a temporary storage site in Rosemount, and when 180 drums have accumulated, they are trucked to a hazardous waste storage facility in Beattie, Nevada.

The cost of this operation has almost doubled in the past five years, Thompson revealed. As a result, much effort has gone into finding reasonable ways to reduce costs. "If you used [a hazardous material] in a reaction and it was deactivated there, then you can do the same thing with the leftover hazardous chemicals. What is left can often go down the drain as a very non-hazardous material," said Thompson. Such conversions done in the lab could reduce the volume of buried wastes by at least 10 to 15 percent, reducing costs as well. Other laboratory conversions could eliminate all but five percent of the present volume of waste, nearly eliminating the present cost altogether.

Photo/Ed Wollack

James Lauer, biosafety officer.

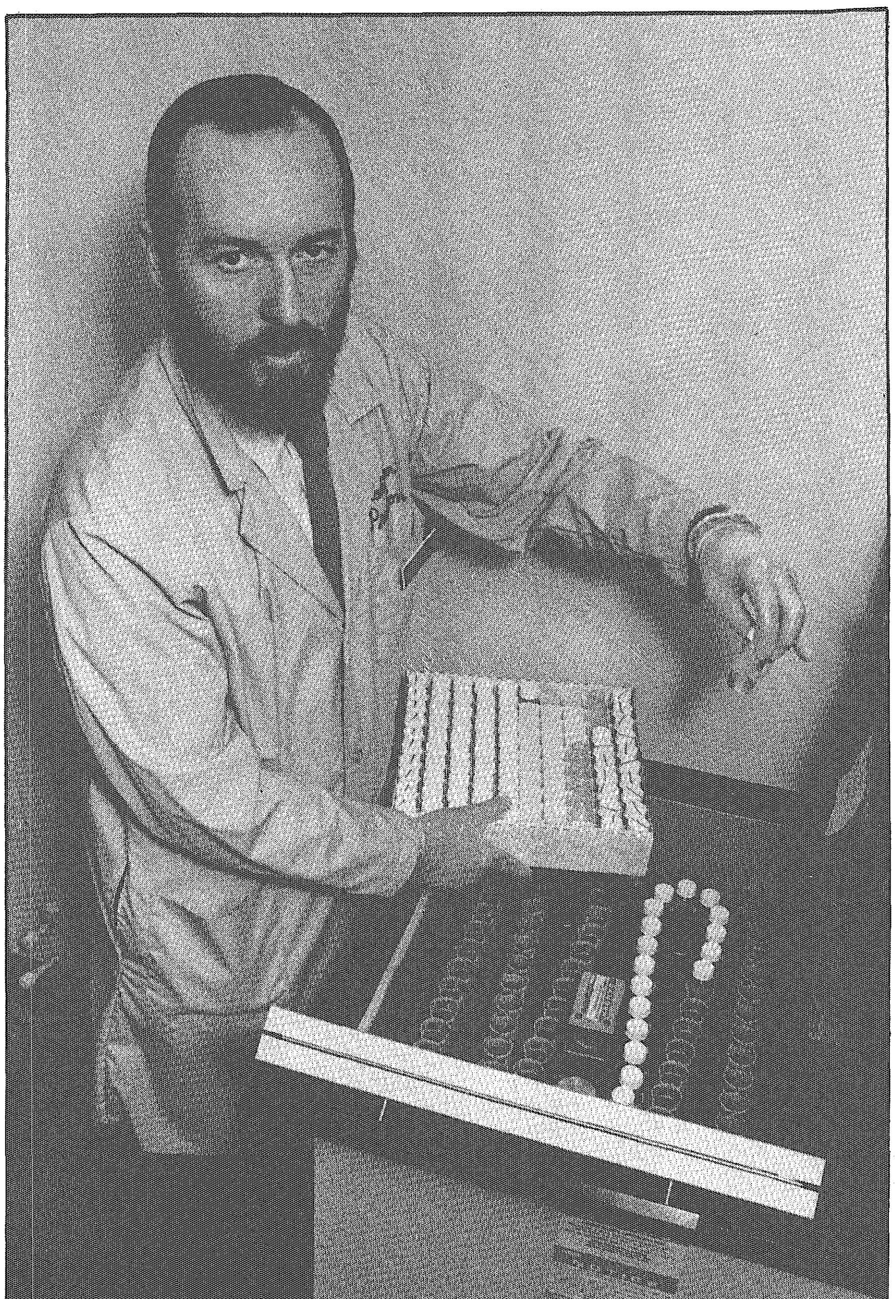
A program for the disposal of radioactive waste was relatively easy to achieve, according to Jerry Staiger, radiation protection officer at EHS. "We had the advantage of having strict Atomic Energy Commission regulations before people were allowed to use [radioactive materials]," he said. As a result, virtually the same disposal program has been in effect for more than 30 years.

A list of compounds to be treated as radioactive waste is made available to each lab involved in radioactive research. As no well-defined safe limits of radioactivity have been found for most of these substances, every waste material which is on the list must be treated as if it represented a threat to safety. Only two substances, tritium and C^{14}, have been studied to determine such safe limits. Staiger commented that similar research "needs to be done for other waste streams."

After hazardous radioactive wastes are identified in the lab where they are produced, they are packaged in either four-milliliter plastic bags or double containment jars (glass bottles inside a metal sleeve) according to whether they are solids or liquids. The Laboratory Safety Services Collection System picks the waste up at the lab and moves it to a central location in the Health Sciences area. The wastes are then packaged into 55 gallon drums according to Department of Transportation and Nuclear Regulatory Commission regulations. About 17 to 18 gallons of liquid radioactive waste can be placed in a drum, the remaining volume taken up by vermiculite. Solid radioactive waste may be placed directly into the drum, filling the entire volume.

The drums are checked for radioactivity and any leakage of material, and transported to the holding facility in Rosemount. When a full load has accumulated, they are trucked to a radioactive waste repository in Richland, Washington, which is presently the only waste site available.

Jerry Staiger, radiation protection officer.



Roughly $100,000 of University funds is spent each year on radioactive waste disposal. According to Staiger, some material is diluted during research (for instance, a small amount of tritium might be smeared on laboratory gloves or filter paper), reducing the concentration and thus the overall threat of radioactivity. To save money, he said, such slightly contaminated laboratory articles need not be treated as radioactive waste, as they once were. Staiger also said expense could be curtailed by not disposing of short half-life wastes but by instead monitoring them for a period of perhaps years until they no longer pose a radioactive threat. Staiger said it makes little sense to bury material that "doesn't need to go [into a dump site] designed for maximum control of exposure potential."

Staiger expressed some dismay that there is "no coordination between hazardous chemical waste management and radioactive waste management. Often the method that's used for disposal may not be the optimum method for minimizing the *overall* risks to the environment and to people." Scintillation vials, small glass tubes used in health science and agriculture research, contain small amounts of C^{14}, and are therefore buried as radioactive waste, he said. But the "main concern is that there is also an organic solvent [in the vial] which is a toxic chemical waste." The vials are buried even though this is not necessarily an appropriate method of disposal for the wastes.

"No agency has that overall view," he said. "They are all looking at one particular area, to the detriment, perhaps, of the overall society."

Even so, Thompson felt that the present programs at the University deserve merit. "While academic institutions are, in general, way behind industry, we've [EHS] certainly been a leader in establishing guidelines for academic waste disposal," she said. Though she praised the cooperation of the University of Minnesota laboratory

Continued on page 32

The Graduate

Making It Big With a Small Company

By Karen Auguston

"You do everything yourself at a small company..."

Eric Anderson
Project Engineer

The other day I was leafing through my I.T. yearbook, wondering whatever happened to old so-and-so. Gus Farell? He has a great job—production engineer over at Honeywell. Mary Sherin? Oh yes, she's in quality control at Motorola in Schaumburg. David Oman? Last I heard he accepted an offer from General Electric. Eric Anderson? Eric's with Cayuna Engine—he's a project engineer. Wait a minute... Cayuna Engine?

If you are from the Brainerd area, you probably know that Cayuna Engine is one of the major businesses in Crosby, Minnesota; there is nothing surprising about that. What makes Eric's job unique is the fact that he is one of the few members of his graduating class employed by a company with less than 100 employees—most new engineering graduates do not initially start to work at a small company.

Why do so many engineers begin their careers by working for a large company? One reason is the kind of companies that typically recruit at the University; most of them are medium to large corporations. Because so many students utilize the Placement Office, these are the companies with which they will most likely accept positions. Of course, many more opportunities exist within large corporations. There are simply more positions available to the entry level engineer. Another reason is that many small companies need the experience and expertise that new engineers do not possess. And small companies often lack the necessary personnel, time, and funds to invest in someone without a proven track record. Sophisticated training programs, typical in larger corporations, are practically nonexistent in a small company.

Small companies are not all alike. The engineer's work environment will vary from office to plant to field, whether his company is an engineering consulting firm or a manufacturer of two-cycle engines. For the engineer who begins his/her career with a small company, it is a unique experience.

Some small companies have facilities in areas not noted for their nightlife; relocating might take some adjustment. Pete Marsnik, Plant Engineer for Hutchinson Technology, Hutchinson, Minnesota, says, "You get used to it [the area]... the drive into the cities isn't bad. I come in for the weekend occasionally." For Eric Anderson, Project Engineer, Cayuna Engine, Crosby, Minnesota, relocating meant "... a more relaxed lifestyle, lower rent, and snowmobiling to work once in a while." Of course, many small companies are located right in the metropolitan area, such as Soil Exploration & Testing, St. Paul, Minnesota, where Tom Flick, manager of the soils and geology department, works.

The starting salary at small companies is average to below average compared to companies overall. However, this figure may be higher depending on the type of industry and an individual's previous experience. Benefits are similar to those offered by larger companies. For example, tuition may be reimbursed up to 100 percent. Hutchinson Technology pays full tuition, including book fees. According to Tom, Soil Exploration "has a fairly strong continuing education program, and most entry-level employees routinely attend seminars." However, unlike many of their larger counterparts, small companies do not normally offer company-sponsored classes.

Eric's training consisted of a four month program during which he worked in various areas of the company, including quality control, production and maintenance. "It was a great way to learn the entire operation at Cayuna," Eric reflected. "And I felt I had a much greater understanding of how everything fit together." Soil Exploration and Testing has a similar internship training program, which also gives the company an opportunity to evaluate new employees. Some training is done very informally. Pete recalled his first day of work as, "... putting me on a project and letting me go with it."

For the young engineer seeking challenges, working for a small company may be the ultimate experience. Responsibility (lots of it), "hands-on" experience, and a wide variety of work all describe working for a small company. Pete Marsnik was put in charge of a project designing a new water system the first day he started work—definitely a "sink-or-swim" situation! Eric completed a fuel pump project this summer which included initial design work, testing, production and visiting area vendors with the finished product. Tom sums up his job by saying, "Variety is the name of the game!"

For an individual fresh out of the classroom setting, the "real world"—where few textbook examples apply—can be a scary place. "After working on my first real project for about half an hour," one engineer recalls, "I was tempted to go back to my boss and tell him, 'Look, I give up. What's the answer in the back of the book?' I was really green!" In a small company the boss may not be able to answer any engineering-related questions. Ir, fact, he/she may be depending on the new employee's technical knowledge and support!

The size of the engineering department will determine the exchange of ideas and information with co-workers. Pete works with approximately forty engineers. There is one other chemical engineer on the staff but he works "at the other end of the plant." Pete finds himself getting on the phone when he needs answers. Eric is the only engineer with a degree at Cayuna. He points out, "With my mechanical engineering degree, they (the managers) think I know everything." (Eric has found it necessary to make an occasional trip to the University of Minnesota for assistance.) Tom, however, has no difficulty getting problems solved. His firm, Soil Exploration and Testing, is a consulting firm employing 85 engineers. Pioneering in the field of geotech engineering, the company has a staff which is among the most knowledgeable in the world.

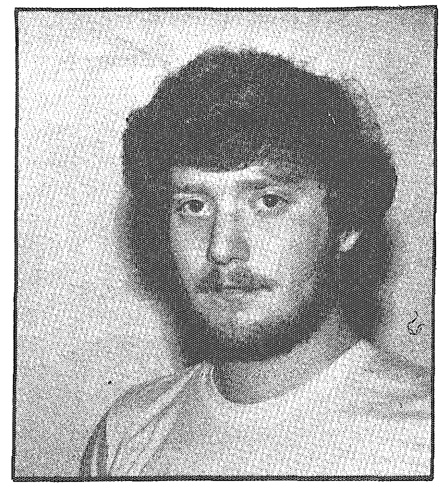
A small company's equipment will probably fall somewhere between state-of-the-art and museum pieces, depending on the company's age and line of business. "All of our dynamic-pile analysis equipment is state-of-the-art because we are pioneering in this area," said Tom. "Cayuna Engine is only five years old," said Eric, "so the equipment is fairly new." If they don't have a large computer system, most small companies will probably have a desk-top model or two. Pete explained, "Although they aren't going to run out and buy a $100,000 piece of equipment, management is very receptive to my input about equipment I need." Getting new equipment is no real problem, confirmed Tom, "if you can justify the return on it."

Because most small companies operate only one facility, the opportunity for travel is limited. However, an occasional business trip may be taken. For instance, Pete traveled to California for a seminar on the design and implementation of the system he had been working on. At a consulting firm, travel may be more frequent. Tom has traveled extensively in the states, including Alaska and Hawaii, on business.

Good advancement opportunities exist in small companies. If the company is in the growing stages, there is an excellent chance for personal career growth. After one year, Eric was promoted to an engineering position supervising two technicians. Tom, who received his degree in Civil Engineering in 1975, has seen his career grow along with the company—he is now a department manager.

If the company is flourishing, expansion and growth support job security and advancement. However, companies which are in the growing stages can experience "growing pains," as Eric Anderson ruefully recalls. With cash flow short and limited production, Cayuna was forced to lay Eric off this past summer. Although Eric was fortunate to be called back in four months, he took a pay cut and a demotion when he returned to work. As production resumes and finances improve, Eric will resume his former duties.

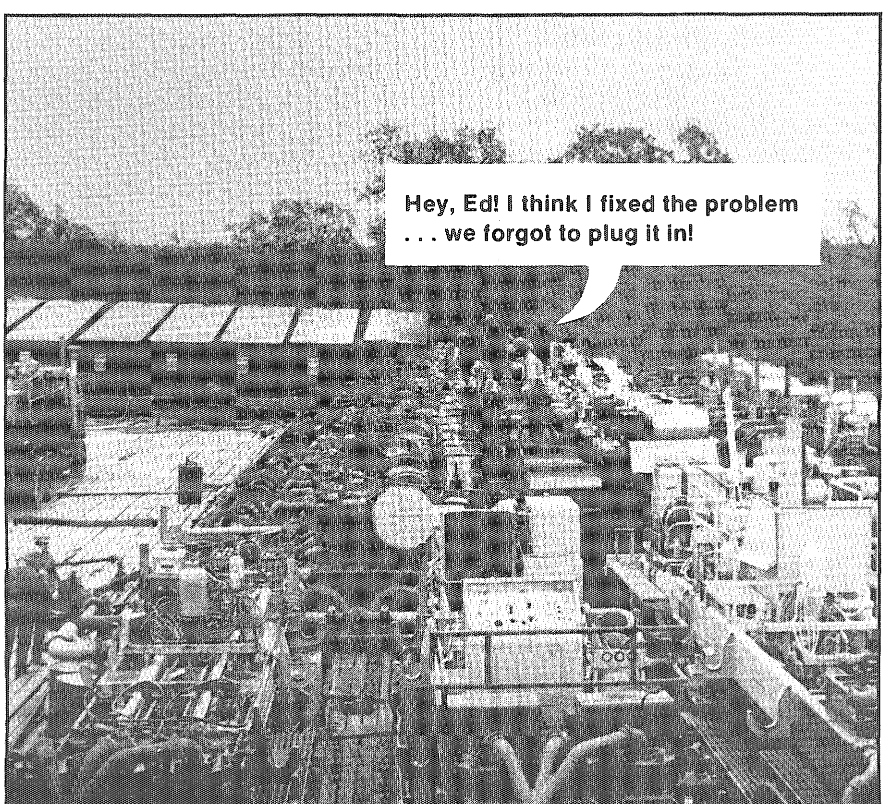
A major difference between small companies and their larger counterparts is the working environment and employee relations. With fewer established policies and procedures, the atmosphere at a small company is often more relaxed and informal. Employees are on a first-name basis with everyone, including the owner. Employees may have a greater input in implementing new procedures. For instance, due to employee interest, a four-day work week was established at Cayuna. At a small company, each employee feels that he/she is contributing to its success. In other words, they care.



Pete Marsnik, plant engineer, Hutchinson Technology.

According to Pete, "There is greater recognition in a small company. When you do a good job, everyone knows who you are. On the other hand, if you goof up . . ." Tom adds, "Soil Exploration definitely recognizes and rewards talent. This is reflected in the company's philosophy of rapid career advancement."

Eric speaks with candor about his job at Cayuna: "I like it alot. It's a friendly place to work." Doesn't that say it all about working for a small company? ■



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Pete Marsnik, Plant Engineer, Hutchinson Technology, Hutchinson, Minnesota.

Dry Scrubbing at Riverside: Demonstrating a New Technology

By Nicholas W. Pilugin

Over the past several years an ever-increasing body of evidence has continued to link power plant and industrial boiler emissions of sulfur dioxide and nitrous oxides (NO_x) with what is popularly known as acid rain. The deaths of lakes and the damage to crops and forests in the United States, Canada, and Europe, have spurred implementation of emission laws in an attempt to control the discharge of these substances. As more and more stringent emission standards are set, utilities and industry have continued their search for ever more efficient and economical Flue Gas Desulfurization (FGD) systems to meet the state and federal regulations. Of the many new technologies available, one of the most promising is spray drying. Developed by the Danish firm Niro Atomizer, spray drying has proven its abilities locally at Northern States Power Company's (NSP) Riverside plant in Northeast Minneapolis.

Founded in 1933, Niro Atomizer has been supplying spray dryers for powdered milk, instant coffee, ceramics, and a host of other agricultural and industrial products. Realizing the potential benefits of dry FGD over existing technology, Niro began developmental work in the mid 1970s, and constructed a pilot plant at their Copenhagen headquarters. Almost concurrently, Rockwell International and several other firms began pursuing similar work, but to date only the Niro spray drying technology has been shown to work satisfactorily for commercial applications.

After Niro's initial pilot plant testing, a demonstration unit was constructed at a small power plant owned by Otter Tail Power near Fergus Falls, Minnesota. To carry out the additional testing needed to fully prove and demonstrate the technology, an agreement was reached to build a demonstration plant at Riverside.

A Short History of FGD

The first attempt at flue gas desulfurization occurred in the early 1930s in England. Intensive development in the United States followed in the 1950s, and some 60 pilot plants in operation at utility boilers during the 1960s. The first commercial scrubber in the United States was finally operational in 1968, and it has been followed by over 62 systems placed on some 18,000 megawatts of boiler capacity since that time.

All of these systems now in operation are of the type known as "wet scrubbers." Employing a water and limestone slurry to react with the SO_2 present in the flue gas, an insoluble sludge of calcium sulfite and gypsum is produced as a waste product.

While wet scrubbing has been effective in its overall removal of SO_2 from flue gases, the economics of maintenance, operation, water consumption, and waste disposal have left much to be desired. As a result, by 1980 some 18 firms were pursuing development of a variety of dry scrubbing systems. With the technology yet to be proven, orders for some 23 scrubbers for utility and industrial boilers were placed during 1981. A comparison of dry versus wet scrubbing illustrates why utilities and industry, traditionally very conservative toward capital investments in pollution control equipment, are flocking to dry FGD.

Dry Versus Wet

A comparison of wet and dry scrubbing can be made in five areas: reagent requirements, waste handling and disposal, maintenance and operation, energy requirements, and economics.

Perhaps the only advantage wet scrubbing enjoys over dry is in reagent requirements. Wet systems are able to utilize cheap, readily available limestone, while dry scrubbers need more expensive chemicals such as lime, soda ash, or sodium carbonates and bicarbonates (such as the minerals trona and nahcolite). Additionally, wet systems have a lower stoichiometry, or ratio of reagent used to SO_2 removed.

Waste handling and disposal, on the other hand, may be the worst drawback to wet FGD. Because the reaction involves the formation of a wet sludge, handling is more complicated than dealing with a powder. Prior to disposal in a landfill the sludge must be de-watered, a process involving centrifugal pumps and vacuum filtration equipment. The resulting waste material must then be "fixed" to prevent leaching by groundwater, and to give the surface of the disposal site sufficient strength to support future construction. In contrast, the wastes of dry scrubbing can be processed by conventional ash handling equipment and are extremely resistant to leaching. The powder is a good landfill material due to its high loading strength.

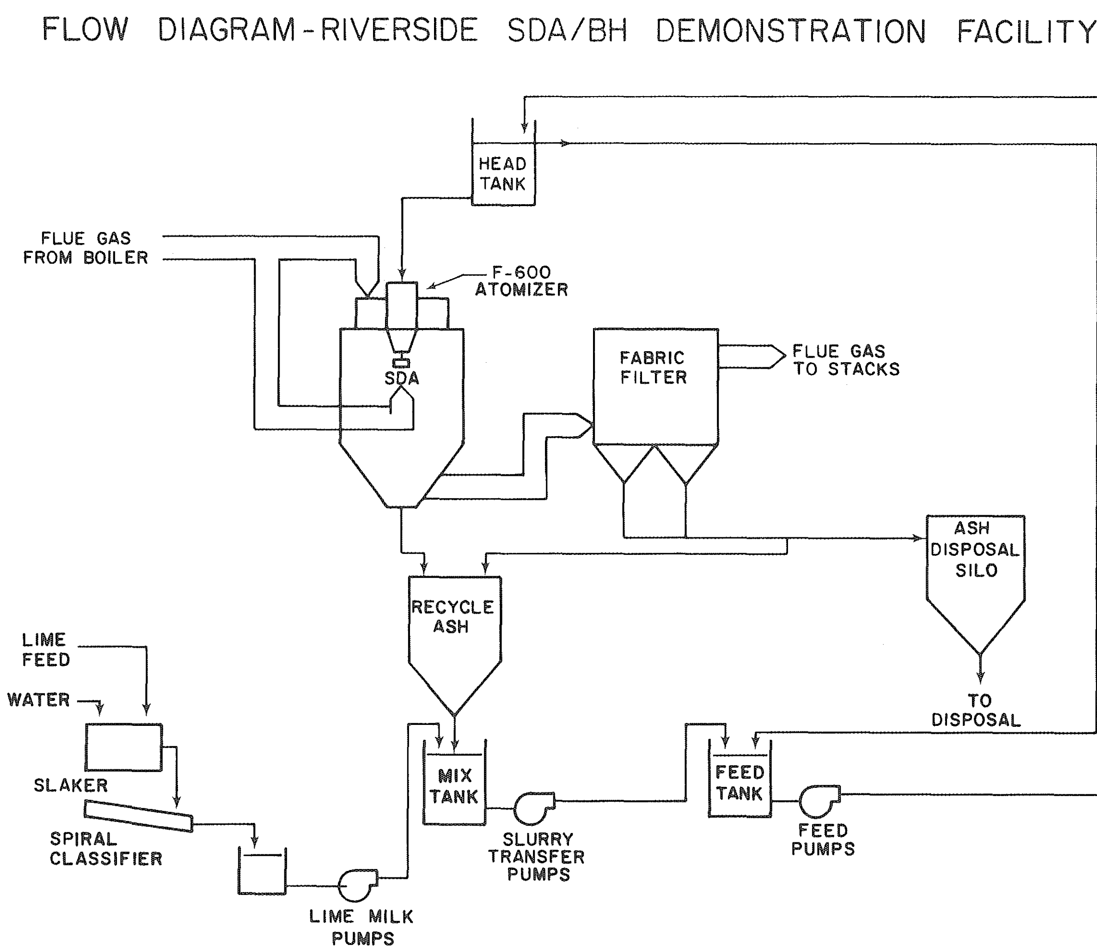


Figure I

Maintenance and operation becomes easier and less expensive as a result of the simpler waste system. Wet scrubbers, in terms of operation and maintenance, also have a disadvantage due to scaling in the adsorber. Because of the flow of large volumes of liquid carrying slaked limestone, some of this solution spatters and drys within the adsorber. At NSP's Sherco units I and II, crews are kept busy full-time cleaning off the scale.

With less equipment to operate there is a corresponding reduction in energy costs. Further energy savings of dry over wet systems come from elimination of reheat systems found on boilers with wet FGD. These reheat systems, used to prevent corrosion of equipment downstream from the adsorber, reduces the plant's overall efficiency. Also a savings is the lower liquid to gas (L/G) pumping ratio for dry scrubbers. Whereas wet units have L/G pumping ratios on the order of 100 gallons of liquid to 1,000 actual cubic feet per minute (acfm) of gas, dry systems typically have ratios of only 0.2 or 0.3 gallons per 1,000 acfm.

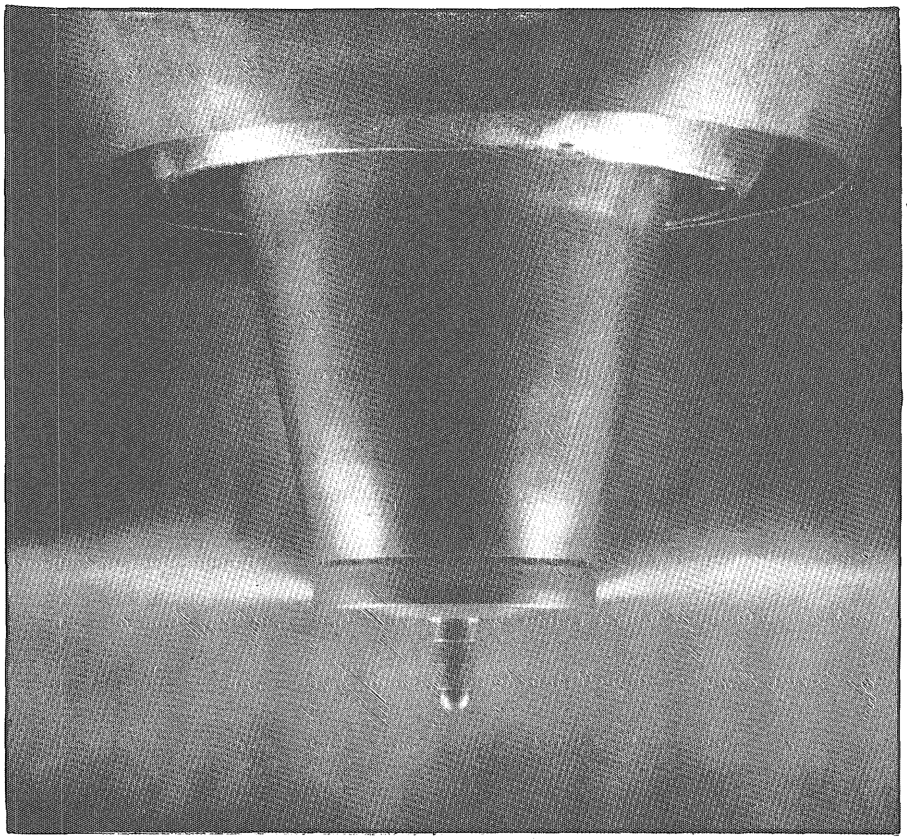
Consideration of all of these factors manifests itself in superior economics for dry over wet scrubbers. With lower capital investment and operational costs, boiler operators should realize savings of 20 to 30 percent over a 35 year plant lifetime.

The Joy/Niro Approach

With its years of experience in spray drying, Niro Atomizer set about approaching dry scrubbing with this perspective. After the formation of a partnership with Joy Manufacturing of Los Angeles, the two firms set about developing a complete system, with Joy responsible for particulate removal utilizing their baghouse technology.

Niro and Joy approached NSP, proposing that a demonstration plant be built at an existing power plant. Riverside units six and seven were selected in part because NSP desired to run Riverside at full capacity (100 MW) but was restricted to operating at only 55MW due to particulate emission standards. Also important in the selection of Riverside was the boiler capacity of units six and seven. At 680,000 acfm, Riverside provided a perfect match to test what could be called Niro's "basic system." Composed of a single Spray Dryer Adsorber (SDA) module, slaking, recycle, and feed systems, as well as a baghouse, the Riverside plant need only be multiplied by the hundreds of megawatts of generating capacity for application to larger plants.

Gas from the two boilers (figure 1)



Courtesy of the Niro Atomizer

Figure 2: the rotary atomizer sprays a fine mist of slaked lime.

enters the SDA module, a circular chamber 46 feet in diameter by 36 feet high with a 60 degree conical hopper. In the chamber roof sits a 700 horsepower rotary atomizer which sprays a fine mist of slaked lime into the gas stream (figure 2). The gas enters the chamber at temperatures between 300 and 350 degrees Fahrenheit and is adiabatically humidified to within 50 degrees of the saturation temperature. The system will run this close to the dewpoint to optimize SO_2 removal with lime consumption. The chemical reaction between mist and flue gas yields calcium sulfite and calcium sulfate. These powders are of low moisture if everything is working properly. On those rare occasions when things *are not* working properly, it comes out as a wet gooey mess.

The powder, once formed, either drops to the bottom of the hopper or is borne along by the gas stream. From the bottom of the hopper, the powder is carried to either the recycle or disposal systems by a conveyor system. Powder retained by the gas is collected in the baghouse.

The baghouse at Riverside consists of twelve compartments, each compartment containing 250 bags which are 35 feet long. As the gas flows through the bags, a "filter cake" builds up on the teflon-coated surfaces. Periodically, each compartment is sealed off from the system, and a reverse draft is forced through the bags to clean off the accumulation. The collected powder is then conveyed to the disposal silo, but could also be recycled.

The Riverside slaking system is redundant, employing both a ball mill and an attrition slaker. This dual system was installed to determine which slaker would be most appropriate for this application. The ball mill is a typical unit, with a rotating chamber containing steel or iron balls which crush the lime, allowing it to slake with the process water. The attrition slaker is comprised of two tanks into which both lime and water are added. A stirrer or other agitation device mixes the ingredients and causes collision of the lime particles against one another, breaking them down in size. On the basis of the Riverside operation, it now appears that the ball mill functions best for this application.

SO_2 removal occurs in both the SDA chamber and the baghouse. During the 10 to 12 seconds that the flue gas resides in the SDA module, up to 85 percent of the SO_2 is removed. As much as another 10 percent is removed by reaction of the flue gas with the baghouse filter cake. Maximum removal efficiency reaches 95 percent overall.

Lessons Learned

Since becoming operational in March of 1981, the Riverside dry FGD system has proven the viability of spray drying for emissions control. Nearly two years of testing has not only demonstrated that the technology works but has yielded insights to improve the system for future commercial installations as well.

The primary test goals of the Riverside project were to confirm scale-up factors from pilot plant to full-size plants, and the verification of SO_2 adsorption and particulate removal by the full-sized system. Additionally, the Riverside plant was constructed with an eye toward investigating operating and maintenance procedures and evaluation of mechanical design and equipment.

Prior to start-up of the Riverside system, fly ash from the plant was shipped to Niro's pilot plant for SO_2 and particulate adsorption tests. Figure 3 shows the excellent correlation between these tests and the results obtained later at Riverside.

The performance of the SDA module operating with the baghouse can be seen in table 1. Stoichiometric ratios during actual operation are comparable to pilot plant values for both high and low sulfur coals. This data, in particular, shows the applicability of the spray drying process to a variety of fuels.

Initial testing of the baghouse verified that particulate collection was within the guarantees made to NSP. Emission levels of particulate were consistently on the order of 0.03 pounds per million Btu's, resulting in stack opacities of less than five percent. These results were especially gratifying to NSP, which needs opacities of 20 percent or less to be able to once again operate the unit six and seven boilers at full capacity.

The favorable results obtained at Riverside have led NSP to select the Joy/Niro system for installation at the Sherco III unit to be built near Becker, Minnesota. An 800 MW unit, Sherco III will have eight SDA Modules and three-16 compartment baghouses of 440 bags per compartment (21,100 bags, compared to Riverside's 3,000). Riverside has further figured in the Sherco III project by its inclusion in an agreement between NSP and the Minnesota Public Interest Research Group (MPIRG). Under that agreement, MPIRG agreed to withdraw its opposition to the Sherco III project provided that, among other things, NSP commit itself to operation of the complete FGD system whenever boilers six and seven of the Riverside plant are fired.

Perhaps the most notable problems encountered and resolved during the operation of the Riverside demonstration plant have been the formation of deposits in the SDA chamber and corrosion of the baghouse interior. Powder deposits were found to result from operation too close to saturation with insufficient feed solids. The wide range of operating conditions at Riverside made deposits more of a problem than would be expected at commercial installations running at uniform loads and temperature ranges. Corrosion of interior surfaces and equipment in the baghouse did not manifest itself until operation at 18 degrees above the saturation temperature was initiated. While the corrosion was not considered to be a significant problem, Joy will add additional insulation around doors and to walls between compartments, particularly for plants that will be firing high sulfur coals. No similar corrosion problem has been found in the SDA chamber and ducts to the baghouse, as these surfaces are protected by a layer of alkaline powder.

Having proven its abilities, the Riverside plant was independently tested by the U.S. Environmental Protection Agency (EPA) and by the

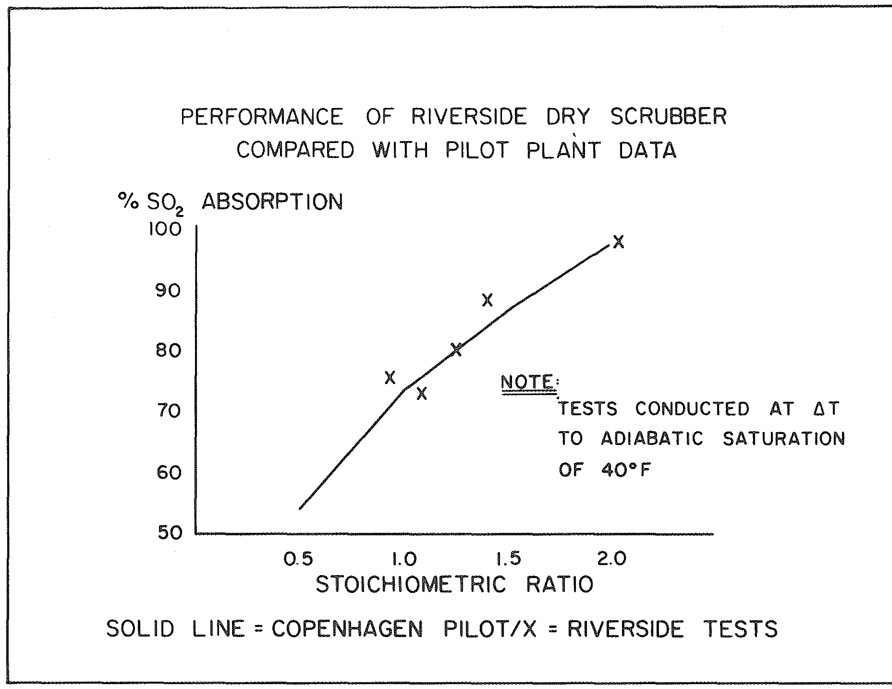


Figure 3

Electric Power Research Institute (EPRI) this past summer and fall. Their test program evaluated whether the plant was meeting New Source Performance Standards for particulate removal and analyzed the system's performance and economics. Tests were also conducted to examine the potential savings of adding a small amount of salt (sodium chloride) to the atomizer feed. The addition of chloride ions aids in the removal of SO_2 in the baghouse filter cake and could reduce lime costs by five to ten percent. Initial EPA/EPRI results presented at an October conference in New Orleans were very favorable.

Similar testing in November by Niro sought to prove that addition of a caustic soda solution (sodium hydroxide) to the atomizer feed would be an effective way to reduce nitrous oxide (NO_X) emissions. Pilot plant studies, verified by initial test results, show that with the addition of 10 percent caustic solution to the lime NO_X removal of 50 percent can be achieved with no significant loss in SO_2 adsorption. This approach toward NO_X emission control causes the ultimate conversion of NO to NO_X to occur in the plant rather than in the open environment. The NO_X is then adsorbed in the baghouse filter cake. Unfortunately, while the NO plume is colorless, the NO_X plume has a dirty-yellow color. This dirty appearance could prove to be a serious stumbling block to implementation of the process on a commercial basis.

The success of the Riverside demonstration project has led to acceptance of the Niro and Joy dry

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Table 1
SYSTEM PERFORMANCE WITH HIGH & LOW SULFUR COALS

	Low Sulfur	***High Sulfur***
SO-2 Removal, %	76 (10 day avg.)	93.6 (7 day avg.)
Stoich. Ratio	0.6	1.37
Approach to Saturation, °F.	18	18
% Solids (avg.)	39	35

Ad Astra

By Scott Otterson

The Changemasters, Rosabeth Moss Kanter, Simon and Schuster, hardcover, $20.25.
A Whack On The Side Of The Head, Roger von Oech, Ph.D., Warner Books, paperback, $8.95.
Moreta: Dragonlady of Pern, Anne McCaffrey, Ballantine Books, hardcover, $14.95.

The American innovative mind? Illustration from *A Whack on the Side of the Head.*

The world is changing fast but American business, as a whole, isn't. American decline in steel, autos, and consumer electronics testifies that our industries are sticking to old formulas that may have worked in the past but which no longer fit modern realities. Studies estimate that in the 1950s the United States produced eighty percent of the world's innovative ideas, a figure which has fallen to fifty percent in the present. What we have here is a failure to innovate. Whether or not American technical people and managers can recover their former brilliance is an open question. But one thing seems certain: If we don't innovate, the Japanese will.

It's not that Americans are becoming inherently less creative, says **Rosabeth Moss Kanter,** but that the way we organize our businesses has become stiff and calcified, stifling and discouraging innovation and the entrepreneurial spirit. As a Yale School of Management professor and consultant to blue chip corporations, Kanter has studied the best and worst management systems, and she summarizes her findings in ***The Change Masters,*** a comprehensive essay on the ills and excellences of the American corporation.

Kanter has found that corporations with "integrative" management (where there is less formal authority and where employees control their own jobs and mix with each other freely) have, over the last twenty years, performed consistently better than those with the old style "segmentalist" management (where there is too much formal authority and where the only control an employee has over his/her job is the employed/unemployed kind which leads to rigid paranoia and a fear of change). Integrative styles like those found in successful hi-tech companies like Hewlett-Packard and Honeywell give employees a sense of self-control, freeing their creative capacities, allowing diffusion of ideas across departmental boundaries, and breathing new life into the enthusiastic entrepreneurial spirit that made the U.S. the vigorous nation that it still is.

Detailed analysis of case studies gleaned from Kanter's experience as a consultant show how this happens in America's most successful corporations. Other case studies show how segmentalist management has killed new ideas that could have helped failing companies. These examples are excellent, and they provide a concrete handle on the subject. This anecdotal evidence is also backed up by empirical studies summarized in an extensive appendix. A few Minneapolis companies get very favorable treatment in *The Change Masters,* and the town that Kanter picks as the center of the new Renaissance in the corporate management—and remember that Kanter is from the East—is none other than our own City of Lakes.

Additional conclusions are that integrative management leads to more socially conscious company policy, eliminating the need for cumbersome government pollution and hiring regulations; that the proliferation of MBA's has distanced management from production, focusing attention on tax loopholes and clever financing rather than product quality; and that the most innovative and profitable management styles require people with strong liberal arts backgrounds. What is all too often dismissed around I.T. as "liberal garbage" has turned out to be crucial.

If I wasn't an unqualified undergraduate (with a weak liberal arts background), I would say that *The Change Masters* is an *IMPORTANT BOOK.* Instead, I will say "read it." As a new employee in a big organization, you may not be able to do much about management, but the insights in *The Change Masters* will serve as a guide for selecting your new employer. Once you're hired, you'll have some idea of how you fit into the big picture. And who knows? Maybe after a few years of hard work, you *will* be able to do something about management.

Innovation on the individual level is the subject of ***A Whack On The Side Of The Head,*** by **Roger von Oech.** A consultant to companies ranging from Apple to IBM, von Oech is an expert on what it takes to become a top notch innovator. His delightful book on ten mental blocks which prevent creativity and what you can do to get rid of them approaches the subject through anecdotes from ancient Greeks like Alexander, not so ancient tinkerers like Edison, and contemporary innovators like Steve Jobs, co-inventor of the Apple computer.

Not surprisingly, the situations that have in the past lead to the "whack on the side of the head" that knocks a thinker out of old thought patterns, are the same situations nurtured by the business environment advocated in *The Change Masters.* Some of the concepts that the two books have in common are that a strict adherence to departmental boundaries prevents new combinations of ideas, and an over-reliance on rules of the past freezes out new ideas when they occur. Another theme common to both books is that innovation in work should be fun, and to that end *A Whack On The Side Of The Head* is spiced with humor and is worth flipping through for the illustrations alone.

It is not only fun to read, but if endorsements from a host of corporate heavies means anything, it must be more substantive than the equivalent of the latest fad diet book for engineers.

> *The excitement of change, the drama of invention captures the imagination in a way that routine, everyday work in a defined job does not.... Changing a part of an organization, inventing its shape can be fun, can be uplifting. And thus, some of the more deadening aspects of work in segmented systems* [*can*] *be alleviated by the opportunity to move beyond or outside of the job to innovate.*
>
> Rosabeth Moss Kanter, *The Change Masters.*

And now for something completely different.

The premise of ***Moreta: Dragonlady of Pern,*** by **Anne McCaffrey,** is that far back in the immemorable past Earth people colonized the planet of Pern. Over the centuries, the colonists forgot their technology, evolving into a sort of primitive feudal society, but not before genetically engineering a strain of telepathic and teleporting fire-breathing dragons which live in a symbiotic relationship with their human riders. The purpose of the dragons and riders is to burn in mid-air the deadly "thread," a parasite that falls into the atmosphere from a neighboring planet and consumes all organic life it encounters.

Before we go any further, I have a couple of things to complain about. First, telepathic dragons are a little tough to swallow. Second, the surface of a planet is a big place, and it seems to me that any parasite worth its salt would come in such numbers over such a wide area as to make any type of air-borne interception impossible—President Reagan's "star wars" technology notwithstanding. But then again, this is decidedly "soft" science fiction, meaning that you have to send on vacation the part of your brain that wants to get down to brass tacks.

Once your reason is on its way to Hawaii, **Moreta** reads pretty well. Moreta is the leading dragonrider of her settlement. Her dragon is about to lay a clutch of eggs, spring is coming and, with it, the cessation of the fall of thread. But a new menace in the form of a deadly plague strikes just as things are looking up, and it is Moreta's task to mobilize Pern's defenses before the plague cancels the dragonriders', and with them, mankind's chances of survival.

The struggle that follows is fraught with enough difficulties—not the least of which is human selfishness—and is packed with enough twists to make the story interesting. The style isn't bad either although there is something in the smug women's intuition and gossiping of the female characters that is guaranteed to annoy even the most tolerant of readers. Nevertheless, *Moreta* is solid and enjoyable escapist fantasy. But approach with caution if you have a low nonsense threshold. ■

Technotrivia ???

By L. Phillip Gravel III

1. Suppose you earned straight A's this quarter and the governor decided to give you a billion ounces of silver. At the same time, some bloke in England is awarded a billion ounces of silver for inventing an eternal tea bag. Assuming you were both poor before your good fortune, which of you would be more wealthy upon receiving your bonus?

2. Moving on to a more precious metal, would you rather have an exagram or a femtogram of gold?

3. Approximately how long does it take for a blue goose to fly from James Bay in Canada to coastal Louisiana, a distance of 1,700 miles?

4. In 1935 a German physics student named Hans von Ohain patented a jet engine design. Later, while working for Heinkel Aircraft Co., he developed an engine designed for 1,100 pounds of thrust. The engine was installed in a Heinkel He 178 fighter and made the first jet flight. When did this flight take place?

5. The flow over Niagara Falls is eroding the shale cliffs away at a steady pace. At its current (no pun intended) rate, when is Niagara Falls likely to disappear?

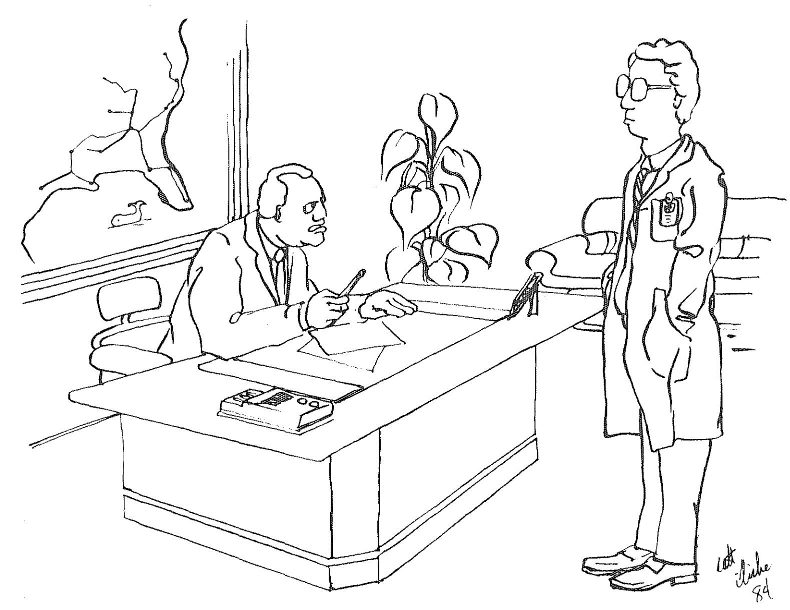
6. In 1934 Wallace Carothers was working for E.I. DuPont de Nemours & Co. Although he never realized it, in that year he made a remarkable discovery when he produced a solution he called Polymer 66. By squeezing this substance through a hypodermic needle, he produced a revolutionary new fiber. What had he invented?

7. At what temperature will gasoline freeze?

8. How is the gauge of a shotgun determined?

9. In the movie "Airport 1984," a passenger-turned-pilot loses radio contact and is forced to land the plane on his own. To do this he must guess the airport's coordinates. What would be the proper guess for the longitude, latitude, and elevation of the Minneapolis/St. Paul International Airport in the Twin Cities?

Trivia answers on page 34



Okay, Heson, you've got your 80 million dollar computer — provided that the chairman can still play "*Space Raiders*" on his terminal.

Lake Restoration from 15
Resources publication, *Survey of Lake Rehabilitation Techniques and Experiences:*

1. *Nutrient inactivation/ precipitation.* Metal ions like Aluminum (III) or Iron (III) are added to the water. The ions absorb the phosphorus in the lake bottom sediments, preventing it from recycling back into the epilimnion, where it becomes available for algal use.

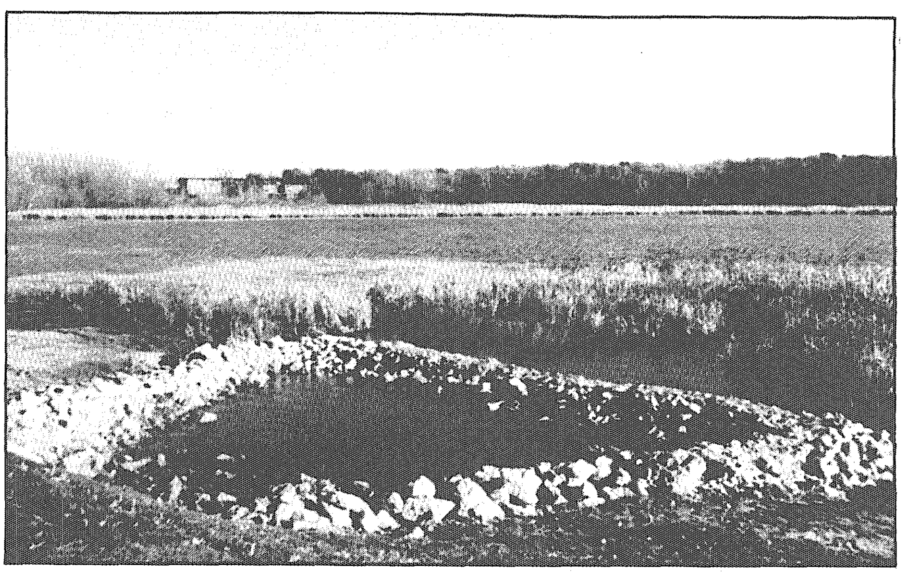
2. *Dewatering/dilution.* Nutrient-rich lake water is pumped out of the system. The resulting desiccation and consolidation of the bottom sediments exposed to air should hinder the release of phosphorus upon replenishment by nutrient-poor groundwater.

(However, groundwater is not always low in phosphorus, as MPCA workers discovered. In the case of the 1977-78 Hyland Lake restoration project, the groundwater used to replenish the system had a phosphorus concentration exceeding the lake water itself. Despite this problem, the project was "considered a success." Water quality still improved, and a fish population was established.)

3. *Biotic Harvesting.* Algae and macrophytes (aquatic plants) remove nutrients from the water to meet their biological needs. Hence, both serve as nutrient storehouses which, when harvested, reduce a lake's nutrient load.

An aerial view of Little Lake Josephine.
Courtesy of the Minnesota Pollution Control Agency

4. *Lake Bottom Sealing.* Lake sediments contain an abundance of nutrients that can recycle back into the epilimnion. Covering the sediments with plastic sheeting, fly ash, clays, and other materials deters nutrient recycling. Hypolimnetic aeration also "seals" the lake bottom sediments by increasing the nutrient's exodation state, promoting the sorption of phosphorus by iron and manganese hydrous oxides.



A diversion outlet running into a sedimentation basin adjacent to Little Lake Josephine.
Courtesy of the Minnesota Pollution Control Agency

These and other engineered lake restoration methods will likely merge with biomanipulation in the future. Yet, even this merger cannot guarantee that the "Land of 10,000 Lakes" will forever have clean, abundant water. Much more money is needed for scientific research, project implementation, and management programs. The latter will ensure that once the lakes are restored, they will remain that way. The federal government allocated only $5 million for all of America's lake restoration projects for this coming fiscal year. Still, this is $5 million more than last year's allocation. Unless funding significantly increases, many of Minnesota's lakes as well as lakes throughout the country could reach the threshold beyond which they cannot be restored. Will Minnesota some day be known as the "Land of 10,000 Polluted Lakes?" ■

Mary Wilkosz is a senior geology major. She is also the assistant editor of *Minnesota Technolog.* Around the office we call the editor "ed." Guess what we call Mary.

TechnoFlog

By Stephen MacLennan
Al Hauser

Engineer on telephone: "Doctor, come quick! My little boy just swallowed my calculator!"

Doctor: "Good heavens, man, I'll be right over. What are you doing in the mean time?"

Engineer: "Using a slide rule."

"So your boy's in I.T. What's he going to be when he gets out?"
"Senile."

At last, after months of intensive searching, we have stumbled upon the vast underlying difference between those two bitterly opposed factions of modern science, physics and engineering. We hereby present to you the fruits of our untiring efforts in hopes of broadening your outlook on this phenomenal situation.

The physicist claims that the inch, by definition, is that given length of thoriated tungsten wire .0563 mm. in diameter which when heated in argon to a temperature of 1535.35 C in an evacuated atmosphere of 5.54 cm. of spectroscopically pure mercury by a current of pi amperes will emit exactly 8.965×10^{10} electrons per second, the measurements being taken under standard conditions. A renowned professor has determined this length accurately to seventeen decimal places.

The engineer, on the other hand, defines his inch as the distance between the first and second joints of his left forefinger.

What Good is a Slide Rule?

"What's the hurry?"
"I bought a new textbook, and I'm trying to get to class before the next edition comes out."

Leif and Woody, two forestry majors, were hauling firewood in their pickup truck from Bainerd to Little Falls. They would buy the wood for $30 in Brainerd and sell it for $30 in Little Falls. After several weeks of this, Leif noticed that they weren't making any money.
"Gee, Woody," he said. "Why do you suppose we aren't making any money?"
Woody, known for his perceptive and logical mind, thought for a while and finally said, "Maybe we should get a bigger truck."

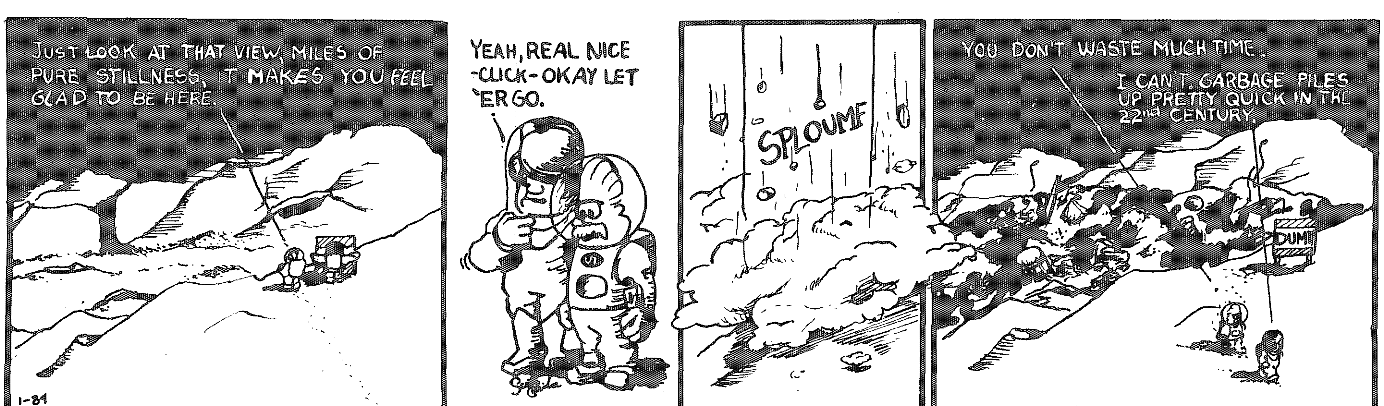
Professor: "That's five times this week that you failed to turn in your assignments. Do you have any comment?"

Engineer: "Yes, sir, I'm sure glad it's Friday."

"I changed my mind."
"Thank heavens. Does it work any better?"

BEBOX

By Scott Ciliske



Brain Teasers

1. You have eight coins, one of which is not up to the standard weight. If you had a pair of balance scales, how would you discover the light coin in only two weighings?

2. Four EE's were in the library, separately preparing for their afternoon lab. The demand for resistors in the lab was very high, and one EE student didn't want to take the chance of not having enough resistors. So he went to the empty lab, divided the resistors into four equal piles, found three left over (which he tossed into a corner), hid his fourth of the resistors and returned to studying. Later a second student, thinking the same way, went to the lab, divided the remaining resistors into four equal piles, found three left over (which he tossed into a corner), hid his fourth, and, putting the remaining three-fourths back into one pile, returned to studying. This process was repeated by the other two in turn.

   That afternoon the pile was obviously smaller than it had been earlier in the day, but, as each student had a guilty feeling, no one said anything and readily agreed when it was suggested that each one take his share and use it for the lab. Accordingly they divided the remaining resistors into four equal parts (with none left over this time) and each took his quarter of the remainder.

   How many resistors were there initially?

Brain Teaser solutions on page 34

Hazardous Waste from 18

workers with regard to the waste disposal programs, she said one often encounters a wall of inertia when implementing a new program. There is a feeling, she said, that "'our people would never do that. I couldn't *possibly* ask our principal investigator to label a waste bottle.' You get to the point where you tell them 'if you don't do it, you don't work with these materials.' And we're at that point now." ■

Scrubber from 25

FGD technology. To date in the U.S., Joy/Niro has four plants operational, four others in start-up and testing, and several others under construction. Given Minnesota's history of environmental concern, particularly for air quality, it seems rather fitting that this viable new technology for controlling the constituents of acid rain has proven itself here. ■

References

Performance Response of Dry SO_2 Removal System of Riverside Station; B. Brown, M. Fitzpatrick, et al. Paper presented April 26-29, 1981, 43rd Annual Meeting of the American Power Conference, Chicago, Ill.

Acid Rain Prevention Through New SO_x/NO_x Dry Scrubbing Process; K. Felsvang, P. Morsing, P. Veltman. Paper prepared by Niro Atomizer.

One Year of Operation of the Riverside Dry Scrubber; J. Meyler, K. Felsvang. Paper presented April 26-28, 1982, 44th Annual Meeting of the American Power Conference.

Riverside Spray Dryer and Baghouse Demonstration Program Test Results; C. Sannes Jr., M. Skinner, S. Wolf. Paper presented by Northern States Power on May 19, 1983 at the 12th Biennial Lignite Symposium.

New Developments in Flue Gas Desulfurization Technology; M. Satriana ed., Moyes Data Corporation, Park Ridge, N.J. 1981.

Nicholas W. Pilugin is a journalism major who has studied math, science, and psychology. Over the past three years, when he hasn't been attending the University, he's been working for Niro Atomizer as a lab technician.

Log Ledger from 7

• Engineers Seen as National Resource Shortage

"One of the greatest challenges of this decade for engineers will be to regain an influential role in the development of the country's industrial future," said Frank Scott, vice president of Harza Engineering in Chicago and president of A.S.M.E.

"Sophisticated as today's world may seem," Scott continued, "things haven't changed much since early civilization. We still base our economy on the market place. And America's leadership role in world markets has been slowly declining for nearly a generation. Today we are not only facing rampant technical illiteracy in a highly technical world, we are also facing a severe shortage of engineers. Without them, we will continue to lose ground in world markets."

Much must be done, according to Scott. He notes that although the undergraduate enrollment in engineering in the U.S. increased in the fall of 1982, it did so at the lowest rate since 1974.

• Solar-Cooled Warehouse Kills Bugs

According to a team of engineers at the University of Virginia at Charlottesville, solar cooling can economically control the cigarette beetle in tobacco warehouses. Currently protected by pesticide spraying, large quantities of tobacco stored in U.S. warehouses for up to seven years are quite vulnerable to damage from the cigarette beetle. According to researchers, it is generally agreed that all life stages of the cigarette beetle can be killed by exposure of at least 40 days at or below 40 degrees Fahrenheit. Because mechanical refrigeration is expensive, the researchers investigated various methods of passive solar cooling—many of which appear feasible—to lower warehouse temperatures. ■

Technopuzzle

By Mark "Dr. Death" Stolzenburg
Dan "The Penguin" Rader
Beautiful Brenda

The new day finds our two fearless friends bound helplessly to chairs in the middle of an Institute of Technology lecture hall.

"Creepin' crosswords, Batman, who do you think is responsible for this? The Riddler? The Joker?"

"No, Robin, this is the work of a far more sinister mind.... Only one villain is capable of such cruelty."

"Leapin' linear differential equations! You don't mean—"

"Yes, that despicable despot of devilry, Dr. Death."

"Holy helplessness, what does he plan to do with us? Let us sit here 'til we starve to death? Place us in the doorway when the bell rings?"

"No, Robin, I'm afraid it's much worse than that. He plans to leave us here so that we're forced to sit through four straight engineering lectures."

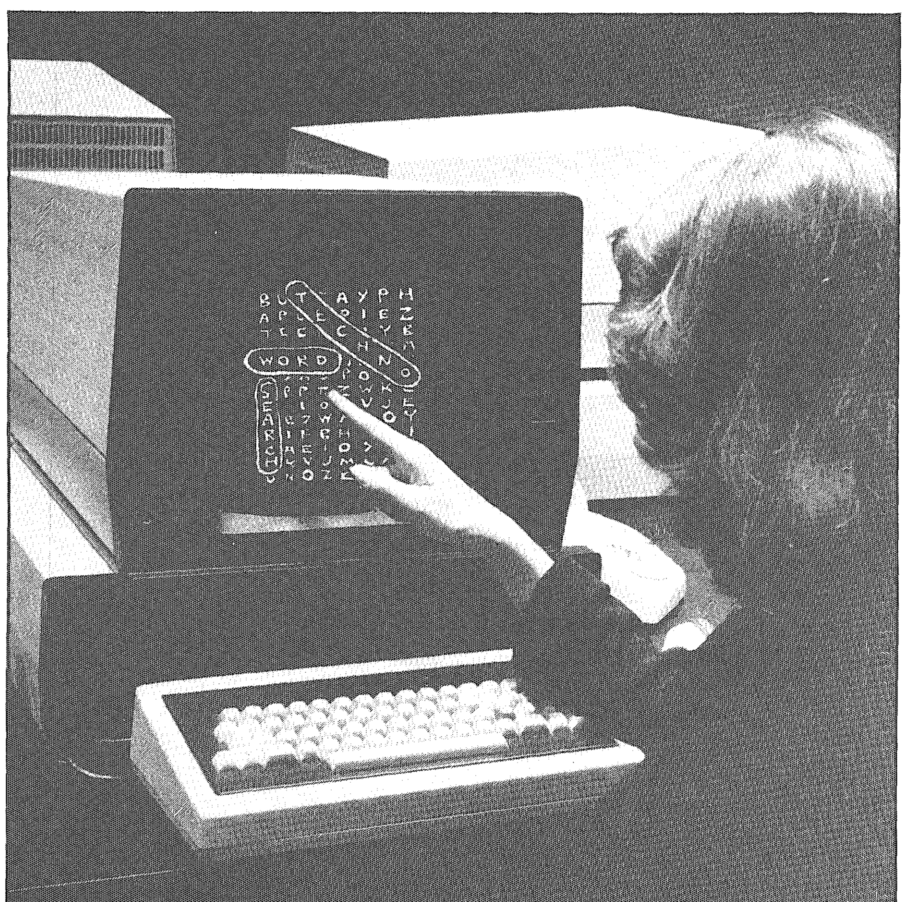
"Bitter barrels of boredom, Batman, is there any way out?"

"Yes, there is one small chance. The diabolical Dr. Death did say that if we solved his word-search game, we would be free to once again protect Gopher City from the evil forces of the world. But I've already run the game through the bat computer without success. Our only hope is to call Commissioner Gordon Murthy and Police Chief O'Grath and ask them to inform the I.T. students of our plight. Perhaps they can solve this perplexing puzzle."

Will this be the end of the Thermodynamic Duo? Or will the students of I.T. solve the puzzle? Time is running out, so grab your solutions and run, fly or take the batmobile to Room #2, Mechanical Engineering. The person who finds the most words in the word-search game will become the proud owner of a "Do I.T. with an Engineer" t-shirt. But don't forget, words may appear horizontally, vertically, or diagonally, backward or forward. Best of luck.

1 A	D	2 D				3 L		4 A	5 L	6 G	E	7 B	R	A
E		8 A	9 P	10 P	11 L	E		12 L	A	O		U		
13 C	14 A	T	H	O	D	E	R	A	Y	T	U	B	15 E	16 S
	17 N	A	D	I	R			18 R	O	O		19 B	P	I
	20 A	A				21 A		22 M	U		23 T	L		L
24 A	L	C	25 O	26 H	27 O	L	28 S		29 T	A	R	E		I
30 L	O	Q	U	A	C	I	O	31 U	S		A		32 D	C
	33 G	U	T		34 T	E	C	H		35 V	I	36 D	E	O
37 C		I		38 T	A	N		39 F	40 O	R	T	R	A	N
41 P	O	S	42 T	A	L		43 I		N		44 S	O	L	V
U		45 I	N	P		46 T	O	47 R	Y			48 P	T	A
	49 G	T		50 E	51 P	A		52 O	X	53 O	54 N			L
55 C	O	I	56 N		57 A	R	58 P	A		59 C	O	60 B	61 O	L
62 F	L	O	P	P	Y	D	I	S	63 K	D	R	I	V	E
	64 D	N	R		65 S	Y	S	T	E	M		66 T	O	Y

Winter 1 Technopuzzle Solution



'Log Smog

I	Y	R	U	C	R	E	M	W	K	E	E	G	O	M	S
N	U	C	L	E	A	R	F	A	L	L	O	U	T	A	O
X	N	A	E	G	D	U	L	S	E	T	O	H	N	T	L
P	S	N	B	L	E	A	D	T	E	E	T	I	U	H	I
H	A	E	N	O	Z	O	A	E	X	U	T	X	C	G	D
O	F	F	R	E	O	S	S	H	O	A	O	J	L	I	W
T	E	A	E	W	B	I	A	M	R	N	X	O	N	L	A
O	R	D	M	E	O	U	Y	Y	A	O	I	E	O	B	S
C	D	O	T	N	S	T	L	O	N	E	C	N	I	N	T
H	T	O	M	T	T	A	C	I	D	R	A	I	N	A	E
E	S	W	S	O	N	E	R	A	Y	F	R	E	E	B	L
M	I	K	P	D	K	E	A	E	R	O	S	O	L	R	E
I	W	L	F	O	S	L	P	C	B	E	Z	O	O	U	C
C	E	I	M	O	E	N	V	I	R	O	N	M	E	N	T
A	L	S	H	P	A	R	T	I	C	U	L	A	T	E	A
L	E	N	O	I	T	A	N	I	M	A	T	N	O	C	L

Brain Teaser Solutions

1. Place three coins on each side of the balance. If the scales balance, the light coin is one of the remaining two. Placing one each on either side of the balance will easily determine the light coin. If the first six coins did not balance, the light coin is in the higher tray. Select any two of these three from the higher tray and place them on either side of the balance. If the scales balance, the light coin is the third coin. If they don't balance, the light coin is in the higher tray.

2. We work backwards on this one. The fourth student left 12xR resistors since he left a pile which could be divided evenly into either three or four piles. He must have found, then, 16xR+3 resistors.

   It follows that 16xR+3 must be divisible by 3 (the third student left 3 equal piles). Set R=3xS, and 16xR+3 becomes 48xS+3. The third student must have taken 16xS+1 as his share. There must have been 64xS+4+3=64xS+7 when he arrived.

   Hence, since this is the number of resistors the second student left, it also must be divisible by 3. Let S=3xT+2. Then the number the second student left is 192xT+135. The amount he took would be 64xT+45. Hence the amount the second student found (and the first student left) is 256xT+180+3=256xT+183. This number must also be divisible by 3. If T is set equal to 3xK, that number will be divisible by 3, and it will equal 768xK+183. Hence the first student must have taken 256xK+61 and he would have found 1024xK+244+3=1024xK+247. It follows that the original number of resistors is 1024xK+247, where K is a nonnegative integer. Choosing K=0, the minimum number of resistors is then 247.

Technotrivia Answers

1. Unfortunately for you, the Englishman would have 1,000 times the silver you would. In Britain, they have a different numbering system than the United States for denominations above one million. In the American system a billion is equal to 10^9 while in the British system a billion is equal to 10^{12}. Source: *Webster's New Collegiate Dictionary,* 1980.

2. You would rather have an exagram of gold. In the SI system the prefix "exa" means 10^{18} and the prefix "femto" means 10^{-15}. Source: Michael Lindberg, *Engineer in Training Review Manual,* Professional Publications, San Carlos, CA, 1982.

3. Sixty hours. Source: Robert M. Jones, *Can Elephants Swim?,* Time Life Books, New York, 1969.

4. The flight took place on Aug. 27, 1939, five days before Hitler invaded Poland. Source: Jones, p. 73.

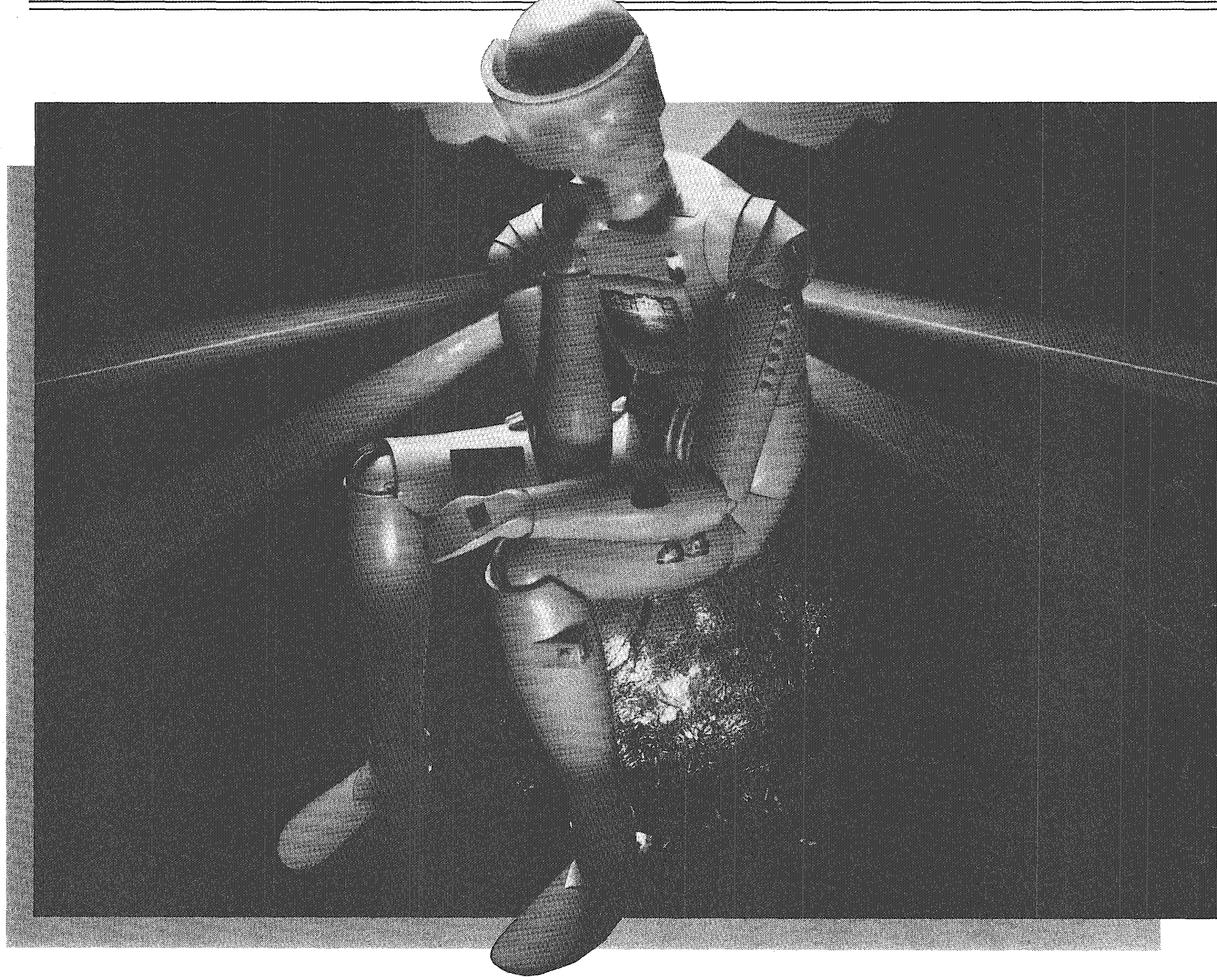
5. Niagara Falls has moved upstream seven miles since it was formed nearly 10,000 years ago. At this pace, the falls will disappear into Lake Erie in some 22,800 years. Source: *Van Nostrand's Encyclopedia,* New York, 1977.

6. He had invented nylon. Carothers never realized what a great thing he had done. In 1937, thinking he was a failure as a scientist, a depressed Mr. Carothers hung himself. Souce: Irving Wallace et al, *The Book of Lists #2,* William Morrow and Co., Inc., New York, 1980.

7. According to the U.S. Bureau of Standards, gasoline has no definite freezing point. It gradually becomes more viscous until it is a solid mass. The temperature at which ordinary gasoline freezes ranges from -180 to -240 degrees Fahrenheit. Source: George Stimpson, *Book About 1,000 Things,* Harper Publishing, New York, 1946.

8. A lead ball that fits snugly in the muzzle is taken as the standard measurement. The number of these lead balls needed to obtain a weight of one pound is the gauge. Source: Stimpson, 1946.

9. The given coordinates for Minneapolis/St. Paul International Airport are as follows: longitude, 93° 13′ 01″, latitude, 44° 53′ 03″, and elevation, 840 feet. Source: Metropolitan Airport Commission.



Create computers that capture the mysteries of common sense.

The brain does it naturally. It wonders. It thinks with spontaneity—advantages we haven't been able to give computers. We've made them "smart," able to make sophisticated calculations at very fast speeds. But we have yet to get them to act with insight, instinct, and intuition.

But what if we could devise ways to probe into the inner nature of human thought? So computers could follow the same rationale and reach the same conclusions a person would.

What if we could actually design computers to capture the mysteries of common sense?

At GE, we've already begun to implement advances in knowledge engineering. We are codifying the knowledge, intuition and experience of expert engineers and technicians into computer algorithms for diagnostic troubleshooting. At present, we are applying this breakthrough to diesel electric locomotive systems to reduce the number of engine teardowns for factory repair as well as adapting this technology to affect savings in other areas of manufacturing.

We are also looking at parallel processing, a method that divides problems into parts and attacks them simultaneously, rather than sequentially, the way the human brain might.

While extending technology and application of computer systems is important, the real excitement and the challenge of knowledge engineering is its conception. At the heart of all expert systems are master engineers and technicians, preserving their knowledge and experience, questioning their logic and dissecting their dreams. As one young employee said, "At GE, we're not just shaping machines and technology. We're shaping opportunity."

Thinking about the possibilities is the first step to making things happen. And it all starts with an eagerness to dream, a willingness to dare and the determination to make visions, reality.

An equal opportunity employer

If you can dream it, you can do it.

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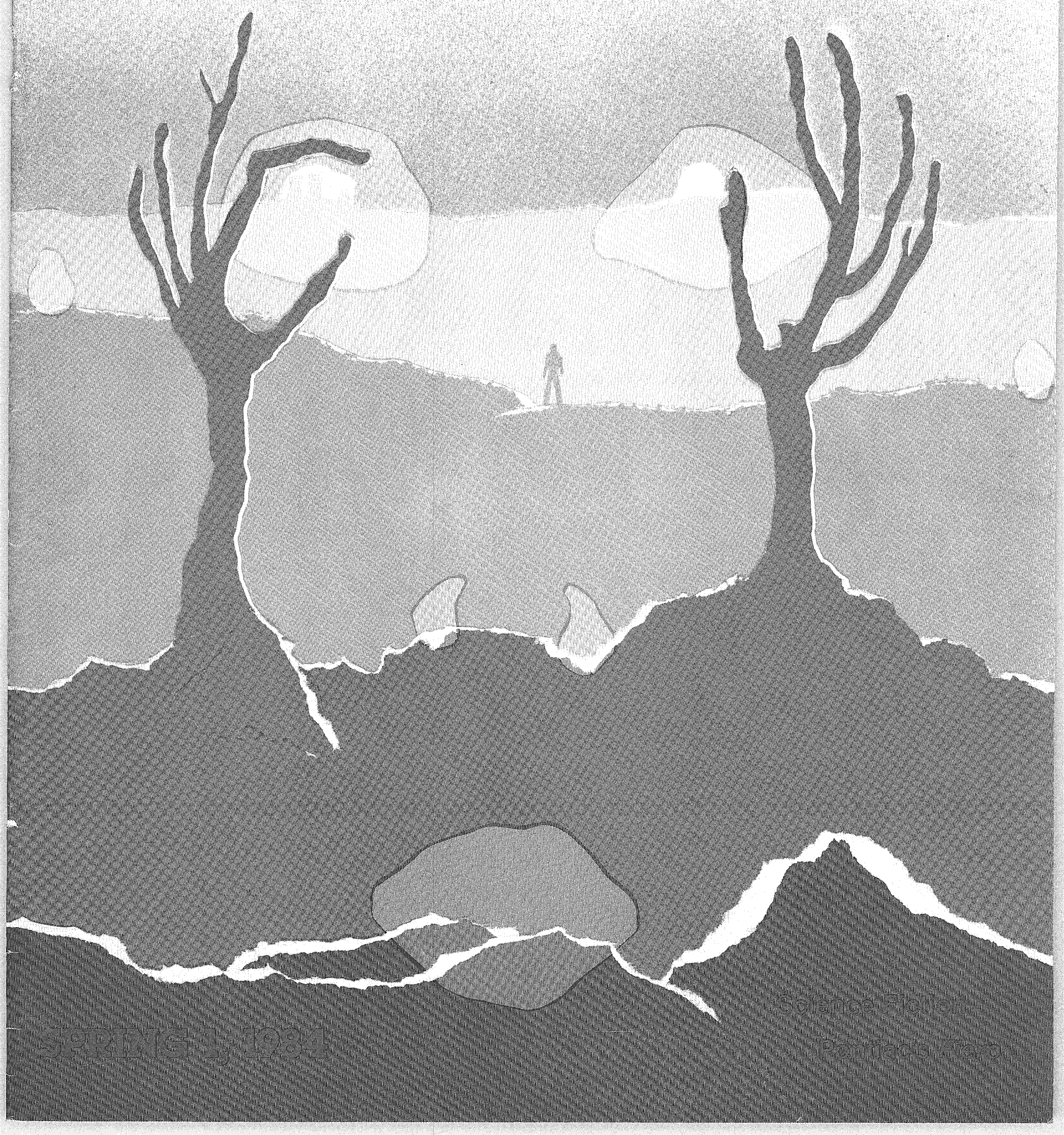

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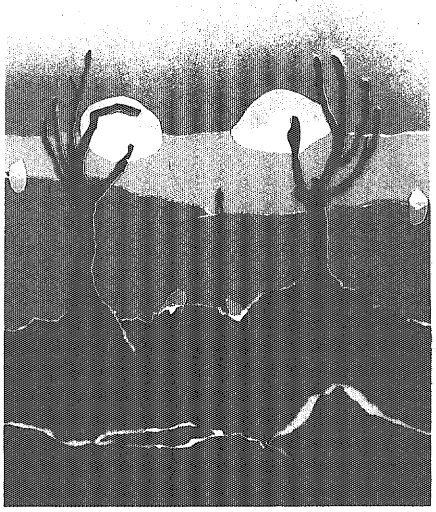

The cover, by senior architecture student Roald Gundersen, illustrates a scene from the science fiction story "Nuclear Summer."

Features:

Departments:

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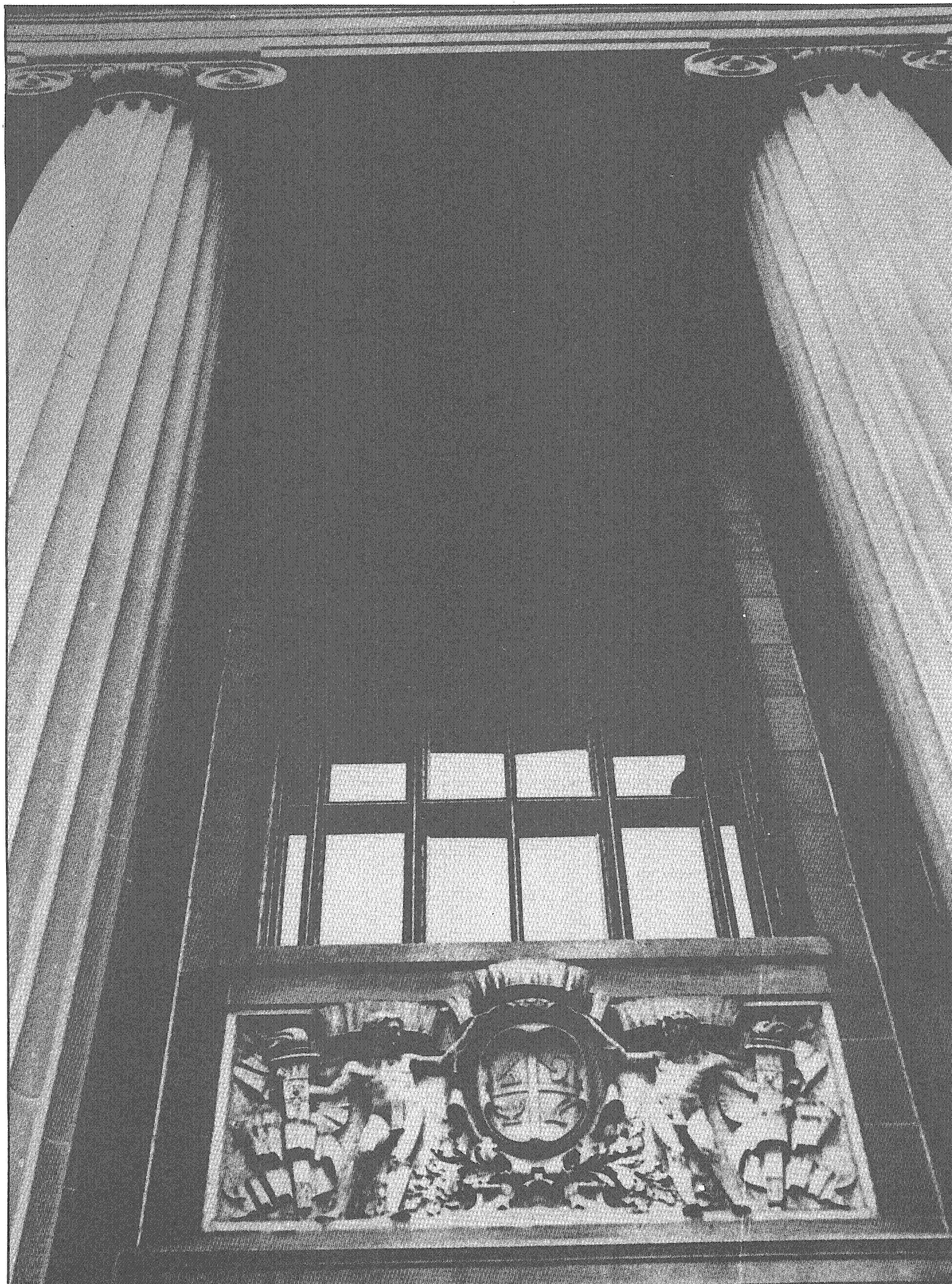

Editor's Log

A Closer Look

Spring quarter is here once again, and with it comes warmer weather, robins, softball and the latest round of proposed tuition increases. If you are a graduating senior, you can breathe a sign of relief, knowing that you have narrowly missed this annual phenomenon... unless, of course, you are considering graduate school.

In this issue's "The Graduate" column, Jim Lundy examines some of the pros and cons of going to graduate school. It is hoped that his article will help the I.T. senior decide whether graduate school lies in his or her future. Jim looks at such factors as increased marketability, opportunity to do research and development work after graduation, and the fulfillment of intellectual curiosity. Unfortunately, financial considerations are now playing a larger role in this decision than many feel is desirable. Indeed, in some cases it is *the* deciding factor. Jim can't help with a student's decision concerning the financial problems of continuing his or her education. Only the University and the legislature have control over the extent of cost increases in the coming years.

I was fortunate enough to be able to sit down and talk to Robert Holt, dean of the Graduate School, about this perturbing situation, and he explained the problem to me as he saw it from the third floor of Johnston Hall. He explained to me that the legislature had decided that tuition should account for 32 percent of instructional costs at the University of Minnesota. The Board of Regents decided that this should be done on the individual college level. In other words, each student in the graduate school would pay for the same percentage of his instructional costs as the typical undergraduate student. Since graduate school instructional costs are much higher (per student) than undergraduate instructional costs, tuition of graduate students would be higher than undergraduate tuition when measured on a per credit basis. But, asked this ignorant editor, isn't it true that graduate students also provide valuable services to the University by being teaching assistants and research assistants? Dean Holt agreed and said that increased aid will be used to compensate students for these services. In fact, he said that at least $1 million more has been authorized for graduate fellowships in 1984-85 than in 1983-84. When this is taken into account, it becomes apparent that the average graduate student is actually seeing a smaller cost increase than the average University undergraduate. Sounds pretty convincing...

I walked back across Church Street into my Mechanical Engineering office and asked some of the graduate students how they felt about the subject. Their answer? "I'd rather have the lower tuition."

Their reasoning was simple. When a student makes a decision on whether he should enter graduate school, part of that decision is based on whether he can *afford* to enter graduate school. Since a graduate degree requires a two to five year commitment, the student must estimate the increases and decreases in cost and aid over that period—no easy task. For instance, it would have been necessary for a student entering graduate school last summer to look into his crystal ball and foresee a 34 percent tuition increase, the addition of thesis credits, another sizable increase in tuition rates this fall, as well as a possible switch from per credit tuition to a flat rate tuition plan. Anyone able to do so probably shouldn't be in graduate school; I'm sure there's a nice position waiting for him or her on Wall Street. Using aid to offset rising tuition costs simply adds one more variable to the overall problem.

In short, the University must start looking at these problems from a student's point of view. It may be an economic fact of life that graduate tuition must go up, but it is necessary that the rise be at a relatively stable rate and that student aid be allotted by using a standardized and nonfluctuating method. Unless half of a graduate degree suddenly becomes a desirable commodity, the alternative to tuition and aid stability will be a smaller number of graduate students—something neither the University nor the potential graduate student would like to see.

Alan Hauser

Alan Hauser

Editor

Coming next issue:

- An Interview with Astronaut John Young
- Space Colonies
- Material Processing in Space
- TECHNOLOG Science Fiction Contest Winner

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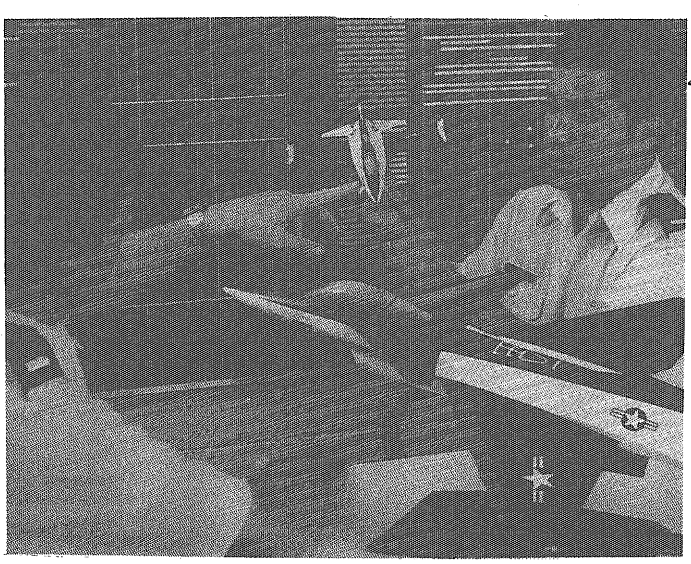
TECHNOLOG



Log Ledger

By Scott Dacko

- **I.T. Student Wins Honeywell Futurist Award**

Roger Aiken, a graduate student in the University of Minnesota's Mechanical Engineering Department, has been selected as one of 10 winners of the Honeywell Futurist Awards Competition. Students across the nation competed against each other in attempting to accurately predict technology achievements that will be reached 25 years from now. Roger's essay was chosen as one of the 10 best, and thus he will receive $2,000 and a summer internship at Honeywell. The competition is an annual event, with the next contest deadline being December 31, 1984. Be sure to enter!

- **I.T. Innovation Fair Held Soon**

Some 16 innovative I.T. students have already entered the I.T. Innovation Fair. And it's not too late for *you* to enter! The competition, sponsored by the Association for Creative Engineering, is a chance for students in I.T. to compete to create marketable products. Seven cash awards, totaling $500, will be given for the seven best innovations. Registration forms and a $10 entry fee must be received by April 19; all entries must be submitted by April 20. All entrants receive an "Inventor's T-shirt." For a copy of the official rules, stop by (or write) the Association for Creative Engineering, 265 Experimental Engineering Building, University of Minnesota, Minneapolis, Minnesota 55455. Questions can be directed to Scott Dacko, 376-2769 or 331-8077.

- **Technological Literacy Requires Teaching Changes**

If American education is to produce technologically literate citizens, the traditional pattern of separating technical education from the liberal arts must be replaced with one that is truly integrated, according to a Massachusetts Institute of Technology (MIT) professor. Edith Ruina, coordinator for the Council for the Understanding of Technology in Human Affairs at MIT, said that while education has yet to figure out exactly how to teach technology so that everyone understands, she is optimistic that it can be done.

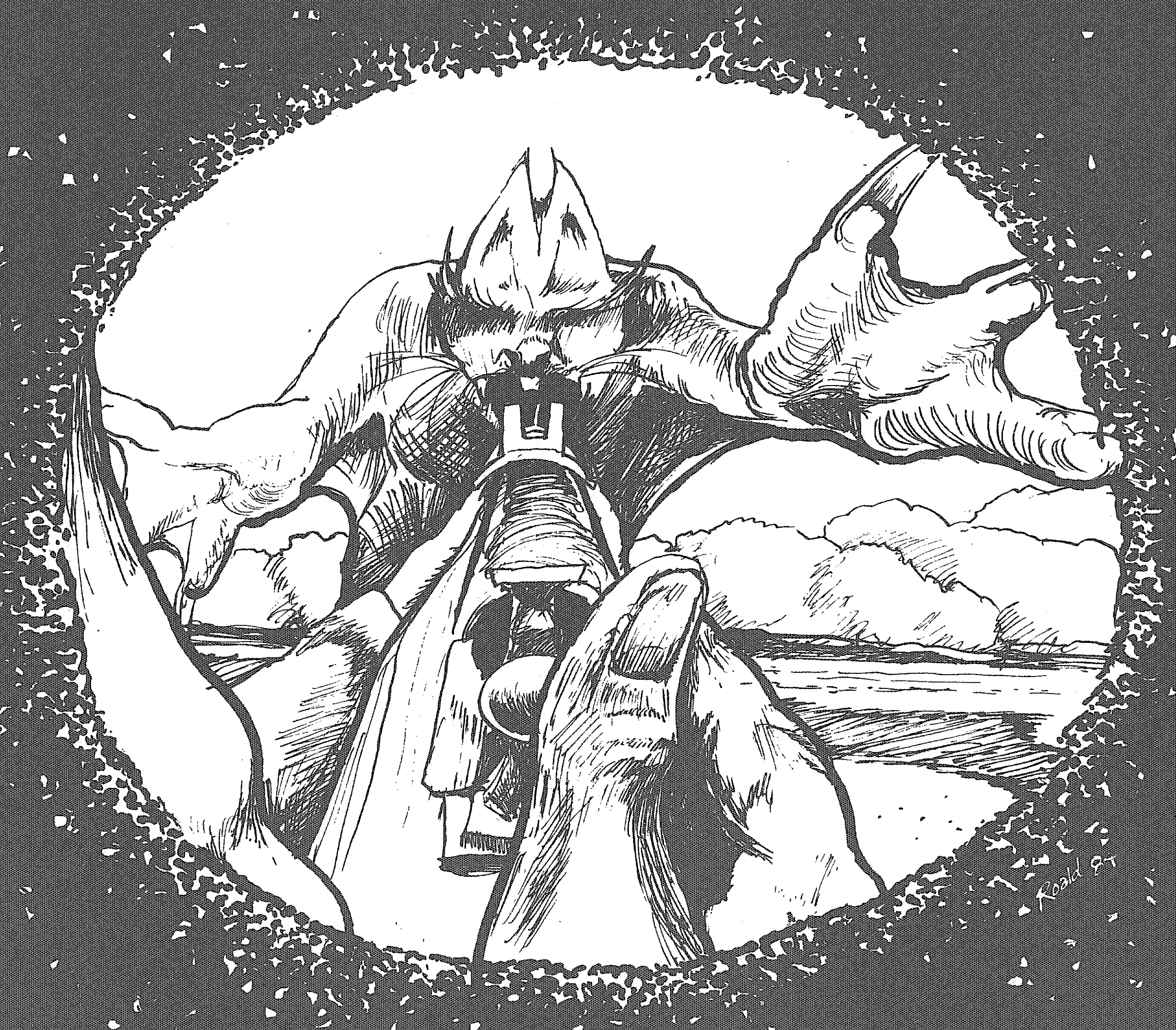
"Through technological literacy curricula, we want students to understand products—automobiles, the computer, nuclear weapons, television, we want them to be able to make intelligent judgments about policy and to be able to evaluate evidence in issues that involve technology . . ." she said.

- **The Future of the Undergraduate Engineering Laboratory**

A conference held at New England College recently discussed the future of a critical element in the undergraduate engineering education: the undergraduate engineering laboratory. Industry and university representatives attending the conference discussed the problem of the continuing trend of poorer laboratory equipment and steadily decreasing level of faculty interest in developing, renewing and teaching undergraduate engineering laboratories. Those present developed guidelines and recommendations for altering the downward trend in quality in engineering labs. A copy of the conference report can be obtained by writing the Publications Department, Engineering Foundation, 345 East 47th Street, New York, NY 10017.

- **Blarney Stone Back, Foresters Fooled**

A member of I.T's Plumb Bob, the organization that puts on I.T. Week, recently joined the Forestry Club and successfully retrieved Plumb Bob's 300 pound priceless rock, the Blarney Stone, which was stolen during last year's I.T. Week. Myron Koehn, Plumb Bob member, convinced the foresters that he was Mike Koehn, a transfer student from St. Cloud who had changed majors three times before finally becoming interested in forest management. Playing dumb, Mike was informed of the age-old rivalry between the foresters and the engineers. Upon being elected secretary of the Forestry Club, he soon learned of the Blarney Stone's hiding place: a storage room in Green Hall on the St. Paul Campus. An hour later, with the help of Myron's roommates, the Blarney Stone was back in the hands of its rightful guardians, Plumb Bob. In its place: a sign that read, "Plumb Bob wuz here." ■



Old Jess

By Steven E. King

Second Place

Science Fiction Contest

When I grew up I was going to be a real Hunter, no matter what anyone else said, I thought to myself as I sneaked along the woody path that wound its way up the old hill. Going as quiet as I could, I hid from the imaginary beasties I pretended were waiting to gobble me up. I wasn't a-scared though. No sir, not me. Real Hunters were never a-scared of anything. And that's what I was going to be, if Old Jess would just give me the chance.

The sudden snap of a twig stopped me short. I froze, hardly breathing, then quickly looked around. So, I thought, trying to sneak up on me, eh? I pointed my Weapon in the direction of the sound, waiting for my attacker. A small fuzzy rabbit hopped onto the path and blinked at me with its tiny pink eyes. As I took a step forward, it scurried away up the path. It knew better than to tangle with a great Hunter and his powerful Weapon.

Actually, my Weapon was just a knotty old branch I found that didn't look like any sort of thing at all. But, since I didn't know what a real Weapon looked like, it didn't matter much to me. I was taking it to show Old Jess, to see what he thought about it. You see, Jess had a real Weapon. He kept it put away somewhere up at his place, but he never showed it to me.

Jess had been a real Hunter. He had been a soldier too, but that was in the really old days—before he came to Island, of course, because there are no wars here. He never talked about the really old days, except to say they were tough times and none of my business. Grownups are like that sometimes. I think some pretty bad stuff happened to him in the old days. He told me they changed him somehow to make him better at fighting, like they do all soldiers. But I don't know about that sort of thing, neither do Mom and Dad.

Old Jess did talk about when he was a Hunter, though. Jess was really old, not just normal old like everybody gets. He said that's the way all soldiers get someday, if they don't get killed. Even so, he was the only Hunter left on Island. Least ways, he was the only one I knew about.

In the old days, like even before my Mom and Dad were born, there were these things Jess called beasties. All I know is they were really big and mean and came from the water somehow or another, but they weren't fish. I didn't know about that kind of thing either. One time I asked my Dad about 'em, and he said that sometimes it's better not to think about something, then you don't worry about it. I knew *I* wouldn't worry, and neither would Jess. He killed a whole bunch of 'em back then, even though they were so tough.

I always asked Jess to show me the scar on his chest. Three long red lines went straight across his body where the skin had healed over the claw marks. He said that's what a youngster like me could get if I messed with a beasty. Not that there was anything like that on Island anymore.

. . . all he did was mumble something like, "I warned 'em," and "They wouldn't listen" . . .

I crossed the stream where the path led up to Jess' door. Nobody much went that way except me, so you kind of had to fight your way through weeds and stuff. Jess never cleared the path to his place; he said he wouldn't be bothered by a lot of visitors that way. I wiped my cheek where a stray branch had whipped my face as I ran the remaining distance. Jess wasn't outside like usual, so I sneaked up to the crusty wooden door and peaked through the open crack. Jess was sitting in his reading chair, the one with the loose spring, and was shining up some long black object that looked like a bent stick.

"C'mon in boy, I know you're here." No one could sneak up on Old Jess.

"What ya got there?" I asked as I slowly pushed open the door and inched my way over to him.

"Nothing that good people would be concerned with," he snarled.

Old Jess was like that; he said stuff about "good people" and never included himself. Mom and Dad didn't seem to think Jess was one of the "good people" either, but I don't know why. Jess was always a little grumpy, but he seemed pretty good to me.

I moved in for a better look at the strange object. As I approached the old chair, I barely heard myself say, "Is that . . . a Weapon?"

It wasn't much bigger than my knotty branch. Just over a meter long, it was perfectly straight most of its length, but sort of bent at the thick end, and had little knobs sticking out the sides. It was smooth, like metal, but it reminded me more of wood.

"Yeah," he growled. "This is my Weapon. So keep yer distance."

I asked him why he had it out, but all he did was mumble something like, "I warned 'em," and "they wouldn't listen."

Old Jess seemed upset about something. His wrinkled hands were shaking as he wiped the cloth across the strange-looking Weapon.

"So what you want anyways?" he asked me. I kind of stumbled for words since I didn't want to show him my branch anymore, not since he had a real Weapon in his hands.

"Well, if ya ain't got nothin' to say, ya best be runnin' along. I ain't got time for no googly-eyed youngsters."

I stammered an apology as I shuffled back towards the door. Jess didn't usually act like that. We would always talk, and he would tell me about the old days when he was a Hunter. Today he was acting different, kind of like the way I act when Mom makes me do something I don't want to do.

I took a last look at him as I backed out the door. All I could think of was how alone he looked, sitting there in his old reading chair.

At supper that night I told Mom and Dad about Jess and his Weapon. They gave each other one of those looks and said they didn't want me to go visit Jess anymore. They said people like Jess didn't belong on Island, and that they thought there was something strange about his sort. I left the table before they started to say something about "good people."

Sometimes I wished Mom and Dad understood Old Jess. He wasn't strange, he just didn't see things the same way other people did. My Dad said when he was young, Old Jess and a couple other Hunters who were still alive then, asked the Council to let them train more Hunters. My dad says they told the Council some nonsense about life cycles and dormant stages, but everyone knew that the Hunters just wanted some more people like themselves. The Council decided not to allow any more Hunters, and destroyed the Weapons when the other Hunters died. Jess would never let them take his Weapon as long as he was alive, but he did agree to obey the Council. He always said, "You can't protect people who don't want to be protected." That was about the time he moved up to his place on the hill.

With my clothes still on, I hopped in bed and quickly checked underneath for a beasty. You could never be too sure. Even though I knew there were no such things as beasties, I still wished I had not left my stick Weapon outside. I wished even more that I was a real Hunter with a real Weapon.

When I woke up the next day, I kept far away from Jess' place. If Dad found out I went there, he wouldn't flavor my food for a week. So I ran down near the water, stick in hand, ready to flush out the beasties that I imagined were lurking around the old log rafts. When I had scared away all the pretend beasties, I took one of the rafts out on the water, grabbing the fishing pole I kept hidden inside an old rotted tree. I paddled out into the deep part. The sun was always warm out on the water, but the past few seasons it had been hotter than usual. I took off my shirt and dropped the fishing line into the water. I leaned back with my stick at my side, trying to lure a beasty by pretending to sleep.

By the time I woke up, the sun was starting to go down, and I hadn't gotten any bites—from fish or beasties—so I started to paddle to shore. Mom had this thing about me being out after dark, so I decided to take the short cut home. I was just rounding the thicket hedge where the marsh meets the woods, when I heard a strange noise. It was not quite like a dog but more like a low rumble-growl. I ducked down into the thicket and tried to be as quiet as possible. I wondered if real Hunters ever *did* get scared.

Then I heard Old Jess' familiar voice yell, "C'mon out, I know you're hidin' around here somewhere."

I breathed a sigh of relief, and scrambled out of the thicket. Good Old Jess; he always knew when I was around.

With trembling hands Jess pointed his weapon at the beast, whose eyes gleamed a violent green, its body covered with yellowish slime . . .

Just then I heard the loud crack of splitting wood and a roar that echoed through the trees like the sound of a huge engine. Large branches were tossed aside in the path of a huge hulking shadow. I turned to see Jess standing not far from it, Weapon in hand. The creature crashed through the trees; it had to be over four meters tall; its long scaly arms as thick as my whole body. Four sharp claws extended from its large webbed fingers.

With trembling hands Jess pointed his Weapon at the beast, whose eyes gleamed a violent green, its body covered with yellowish slime. With a sound like a clap of thunder, the Weapon discharged a bolt of energy that ripped through a tree, splitting it clean in half, right behind the beast.

With its killer instinct, the scaly monster lunged forward at Jess, who seemed to be frozen motionless in the mud. At the last moment Jess ducked aside; but not before one of the beast's huge claws had slashed open a long deep gash in Jess' arm. The precious black Weapon slipped away from his grasp. The beast reared back, trying to use its powerful hind legs to crush the life from its victim. Jess crouched down, then sprang in an incredible leap, landing near a tree many meters away. I stared in amazement, trying to believe what I was seeing. Then Jess grabbed a hardwood branch, one as thick as my

arm, and ripped it right off the tree. He began to swing it above his head, all the while screaming taunts at the beast. The monster roared a challenge, its fangs clamping in anticipation as it closed in on Jess.

Then I saw it, the long, black Weapon, lying in the grass not far away. All I thought was that I had to get it to Jess. I scrambled towards it, but tripped and fell into the muddy grass as I clutched at the fallen Weapon. I looked up in time to hear Old Jess scream as the beast's claws gripped his body. Jess took desperate swings at the beast's jaws as the creature made its final attack.

Trying to remember all Jess had ever told me, I pointed the black Weapon at the monster's huge back, and squeezed as hard as I could. The lightning blast of the discharging Weapon threw me back, slamming my head against a low hardwood branch.

I guess Jess woke me up because he was standing over me with the Weapon in his hands. I noticed he wasn't bleeding. His wounds seemed to be healing in front of my eyes, leaving long red scars where the beast had ripped open gashes. With a gasp, I remembered the beast and turned to see the huge carcass lying face down in the mud. A huge black hole was in its back.

"C'mon kid, I best be gettin' you home," Jess said as he pulled me up.

I couldn't help but look at the beast as we walked back through the thicket. I tried to think of the day before, when all you had to do was pretend beasties didn't really exist; then you were safe.

Old Jess had always seen things differently. ■

Steven E. King is an aerospace engineering junior who says he doesn't really believe in beasties.

Minnesota Technolog *hopes you enjoy this issue's science fiction winners. The first place story will be printed in our Spring 2 issue.*

Nuclear Summer

Third Place
Science Fiction Contest

By Jon Chaffee

Charlie's thoughts never drifted far before the incredible irony of the situation hit him as hard as the nuclear accident had hit the landscape. Here people were all scared out of their minds about nuclear disaster, about a war to end all wars, about nuclear proliferation, about the arms race, and then a small band of lunatics comes along and uses army surplus World War II artillary to depopulate an entire city and the surrounding countryside. People spent all of their time worrying about megatonnage, and then less than a ton of TNT did the damage people normally associated with a neutron bomb.

Charlie paused in his thoughts to take in his surroundings. He was walking through somewhat rough wooded terrain. There was no path so he was struggling constantly to forge a new trail. He was making his way along the main highway, following a course parallel to it but about 50 yards away. It would, of course, have been much faster to walk right on the highway, but it was important for him to stay out of sight.

Charlie paused by a stout oak trunk and leaned his heavy frame against it. It was the closest he could come to genuine relaxation while wearing his radiation shielding suit. The entire thing was made of lead, and it made his movements difficult and strained. But it was necessary. The radiation had diminished since the terrorist attack on the nuclear power plant, bu it was still at very dangerous levels. Charlie removed his geiger counter from his pack, powered it on, and watched the indicator light flicker like a rock concert strobe. The light served as a constant reminder of the peril he had placed himself in by entering what had been termed by th popular press, "the dead zone." Charlie looked around him at the evidence which indicated the appropriateness of that terminology. Everywhere he looked was evidence of death and decay. All of the flora was defoliated. No birds graced the sky, no animals rustled through the non-existent underbrush. Everything was still, and there was an eerie silence permeating the landscape.

Nonetheless, the remnants of the woods afforded him a reasonable amount of cover. The government strictly forbade anyone to enter the dead zone, and rumor had it that the policy governing the security patrols was on the order of "shoot first and ask questions later." Charlie had no desire to get shot or to expose himself to harmful doses of radiation.

"Why then," he asked himself, "am I here, where the chances of getting shot or getting leukemia are so great?"

Ostensibly, his plan had been to return to the small rural town where he had formerly owned a house and retrieve whatever valuables still remained there. He also had some sentimental reasons for wanting to see his house again. But Charlie knew that these reasons by themselves would not have compelled him to take the trouble or the risk he was now involved in.

There was something else driving him. Perhaps it was natural curiosity, a desire to see the dead zone from the inside. Perhaps it was the adventure of it all, that emotional rush he always felt when he did something forbidden. It may have even been his way of lashing out at the government. Perhaps by defying the government he was expressing his anger at them and at everyone else for what had happened. Charlie had cause to be angry. His wife and two daughters had died from radiation sickness several weeks after the catastrophe.

All of these things probably had something to do with Charlie's present situation. But Charlie knew that there was something else. A feeling inside that kept trying to tell him something was wrong. At times Charlie felt like a paranoid fool. But he was very suspicious about some of the precautions the government was taking. Like the fact that no commercial airliners were allowed to fly over the dead zone. And Charlie had decided that he had to find out, if he could, whether there was really any reason to be suspicious.

Charlie hoisted his pack onto his shoulders and began to walk again. He tried to walk quietly, but could not avoid making some distinctly human noises. Silence covered the land like a blanket, and the sounds of twigs snapping and old dry leaves crackling seemed to carry forever. But there was nothing Charlie could do about the noise, or the silence.

Suddenly Charlie heard the noise of a jet plane off in the distance. One good thing about the silence was that it allowed Charlie to hear the approaching planes while they were still quite some distance away. This afforded him time to hide, although the grey-brown color of his lead suit served to camouflage him well against the bland, dead background.

Charlie propelled his bulk into the shadows behind a gnarled old tree trunk. He took a position that allowed him to peer out and up at the sky without being seen from above. He watched the small airforce reconnaissance plane fly low over the barren landscape.

"They sure do a lot of reconnaissance," he thought. He felt another dose of suspicion being added to his steadily increasing store.

Charlie listened to the jet stream off into the distance, noting the sudden decrease in pitch as the Doppler effect did its thing to the sound waves. Charlie listened carefully to the noise, basking briefly in its company.

"A measure of the quality of my new life," he thought dolefully, "that I depend on the sound of jets to keep me company."

The sound receded until Charlie couldn't tell if he was hearing the jet or only the blood rushing behind his ears. The silence left him feeling empty, isolated, alone. But he carefully kept any thoughts of his dead family locked deep within the confines of his mind. Charlie did not want to break down. And he knew that thoughts of his lost Alice or his missing Becca and Megan could easily push him over the edge.

It was starting to get late. The first hints of twilight gloom began pushing themselves against the grey trunks and branches. Charlie trudged on as the shadows deepened and stretched themselves toward the east. Charlie looked up at the overcast garnet-colored sky.

"Damn," he thought, "there'll be no moon tonight. I'll have to stop soon and spend the night resting. But I wish I could travel at night. It's slower, but there's less chance of being seen." Unconsciously, Charlie picked up his pace, trying to get as much ground covered as possible before nightfall.

Before it was too dark to see, Charlie found himself a place to sleep, or at least pass the night. Since the nuclear accident Charlie often found sleep difficult to come by.

Charlie liked to stay out of sight when he retired, even if it was a pitch black night. He didn't want to oversleep into the daylight and be exposed to the scrutiny of the overflying planes. Not that he expected sleeping too much to be a problem for him. But he didn't want to take any unnecessary chances.

This night Charlie found an outcrop of rock on the northern side of a hill surrounded by tall but needleless conifers. The situation was sufficient to provide him with the appropriate cover. He settled himself down on a bed of crisp brown pine-needles and watched night squeeze the light out of the radioactive twilight.

Charlie resisted the urge to take a reading with his geiger counter. The blinking light, as dim as it was, might put him in danger.

"No unnecessary chances," he thought. He drew on his water tube and made a mental inspection of his physical condition. His back ached from lack of rest and over-exertion. Charlie had to sleep and rest sitting up. The heavy water tank on his back prevented him from assuming a prone posture. The water was heavy, but Charlie depleted it slowly and sparingly. He only had a limited quantity and did not want to run dry. But he was dehydrated. His lips were chapped and sore, his mouth felt dry and sticky, and his throat ached.

Had his thirst been his only uncomfortable sensation, it would have been more noticeable. But his discomfort was augmented by the fact that he had not bathed or changed in the three days of his journey. The lead suit was hot, and the excessive strain of carrying it together with the constant exercise of walking miles every day made him sweat profusely. Everywhere his skin was sticky and clammy, and he could smell the odor of his body in the contained atmosphere of his suit.

Charlie continued with his mental

inventory. But all he discovered was pain. Every muscle in his body ached. And his stomach growled its displeasure, a dull ache attesting to its empty state. Charlie fumbled in his pack for a food module.

"The good thing," he thought, "is that the more supplies I use up, the lighter my load becomes."

With that thought in mind, he took a big draw off his water tube and felt his parched throat assert its thankfulness. He tried to ignore the formidable question that was knocking on the door of his consciousness, but it wouldn't go away.

"Will I have enough supplies to make it there and back?" Charlie shuddered, and tried to shift to a different train of thought.

He began contemplating his journey so far. He was sure this was the end of the third day. He compared his progress against the mental map he held in his mind's eye. His progress had been acceptable. He was at least 60 miles into the dead zone. If all went well he'd reach his village the next day.

"I'll probably have to wait until it's dark to try to get into my house," he thought. "I wonder if anything's still there. I wonder if there'll be soldiers in the town. I wonder if they'd shoot me if they saw me. I wonder..." and wondering and wondering, Charlie collapsed into a fitfull sleep, the food module still clenched in his hand.

Charlie didn't realize the extent of his exhaustion. The hard work, uncomfortable conditions, shortage of food and water, anxiety over being seen, repression of his thoughts about his family, lack of sleep, and exposure to beta and gamma radiation all combined to push him into a state of extreme fatigue. Charlie ignored all the signs, or attributed them to other things. So he didn't know that he was near his own breaking point. Two years of grieving about his wife and kids just didn't seem to be enough for him.

Charlie slept long, but not well. His sleep was filled with dreams about Alice, about his children, about Sunday barbecues in backyard sunshine, school plays, joyous sessions of love-making, quiet so as not to wake up the children. But all of these dreams ended with the same nightmare. Skeleton-like faces with skin hanging loosely from creaky bones. Faces peering out from behind thick plexiglass. The faces of his wife and children as he saw them at the government radiation sanitarium days before their death.

The faces had been horrible, but Charlie's nightmare mind made them even worse. He saw hollow-eyed skeletons with toothy snarls, as the devil giggled morosely in the foggy background. Alice's skeleton eyes could not disguise the wailing sadness he had seen back then and saw clearly now. His children's fear turned to sheer terror as a roomful of skeletal victims surrounded and engulfed them. He heard Megan's tiny voice, protruding from a dying mouth surrounded by the face of an old woman. Megan was eight, but bald and with wrinkled skin, she looked like she was eighty. "I'll see you in heaven, Daddy." The voice repeated itself, over and over, echoing in Charlie's mind as if it were an empty cavern. "I'll see you in heaven, Daddy." The voice repeated itself, faster and faster. "I'll see you in heaven, Daddy." The pitch became higher, the repetitions came faster and faster until Megan's voice became a high-pitched scream. Suddenly Charlie saw a vague, diffuse, intangible entity superimposing itself on his daughter's fading grimace. As the scream's volume grew, the grimace turned to a grin, and quietly, but mysteriously more audible than the scream, the devil's chuckle made itself known. As Charlie's view became filled with a grotesque and monstrous devil's face, he was aware of his daughter

spinning and spiraling downward. "I'll see you in heaven, Daddy." The voice was quiet, and faded to nothing as the last sentence was uttered. Against an empty, black background, nothing could be seen or heard except for the devil's deep, foreboding laughter.

Charlie woke with a start. Had such a movement been possible, he would have bolted upright. But he was already sitting up. And his heavy garment made bolting in any direction impossible. Charlie was sweating. But this time it wasn't the hot, sticky perspiration of exertion, but the cold prickly release of a man on the edge of panic.

It was still dark out, but things seemed much different. A brisk breeze swept across the barren earth, playing a morbid melody of the wavering limbs. The clouds had dissipated, and a bright, starlit sky cast an eerie glow on the land. Charlie struggled to his feet, trying to shake himself out of his nightmare. Clinging precipitously to a few hanging tendrils of reality, he managed to convince himself that he was not hearing the devil's violin, that the devil was not lurking in the shadows behind the next tree. Thoughts of his wife and his children quickly receded to the depths of his inner self, where they were once again locked away with the key of reason.

Charlie gathered his belongings and began to move again. Soon a reassuring glimmer of morning adorned the eastern horizon. Charlie stepped up his pace, trying to leave the darkness behind.

It was late afternoon when Charlie began ascending the rise on the outskirts of town. He was truly fatigued, tired to the bone.

"I need some rest," he thought. "Perhaps I should wait here until nightfall and try and get some sleep."

But competing with this sensible idea was Charlie's intense desire to see his old hometown again. This desire was enhanced by Charlie's sense that he should keep moving. He feared that something hideous lay just behind him, that he had to keep running from something. The seeds of paranoia that had been caused by a reasonable suspicion had taken root. Fertilized by Charlie's fatigue, the paranoia had grown strong.

Suddenly Charlie saw something at the brow of the hill. Amazed, he witnessed the culmination of his wildest, most fantastic and hopeful dream. There, running down the hill toward him was his daughter Megan. Overjoyed, Charlie forgot about his constraining costume and attempted to bound up the hill toward his daughter. But gravity could not ignore the heavy suit. The sudden jolt of his head meeting the earth brought Charlie back to awareness. But the weight of his water tank squeezed him against the ground, forcing all of the air from his lungs and threatening to crush the life from him. Charlie agonizingly rolled to his side where he lay gasping for breath for several minutes.

"I'm hallucinating," he thought. "I must be more worn down than I realized. I better get some more sleep." He got up and stumbled to a nearby tree.

But try as he might, sleep continued to elude him. Whenever Charlie shut his eyes he saw the wrinkled face of one of his daughters or the sad brown eyes of his dying wife. Sadness engulfed him, and he cried by the tree for several hours.

It was near dusk when he decided to drag himself up. The sun had spread itself against the western horizon, and Charlie, thinking of Eliot, tried to make it fit into the shape of an etherized patient. A sense of irony began sneaking up on him as he thought of the nuclear furnace that was the source of all life on earth. "It's fine out there," he muttered out loud, gaining comfort from the sound of his own voice. "Sailor's delight." He spoke out loud again, noticing the sunset's rosy hue.

Charlie felt more drained than ever after his emotional release. But the thought of seeing his town spurred him on. Slowly, mustering all of the strength he could, he dragged his feet up the rise.

Charlie stepped slowly but steadily. He thought carefully about each step, trying to keep his wits about him by focusing on the mundane. It worked. He reached the brow of the hill.

Charlie had his eyes shut. He was delaying his first view of the town until he could take it all in at once.

What he saw astounded him. Off in the distance, on the other side of

Continued on page 22

The Logical Suspect

Soot particle growth as it takes place in wood-burning fireplaces, diesel engines, and industrial furnaces, has been attributed to a complex set of interdependent chemical reactions. A researcher at the General Motors Research Laboratories has demonstrated that the decomposition of a single species is primarily responsible.

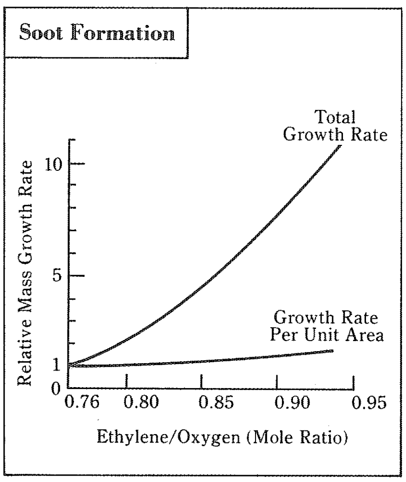
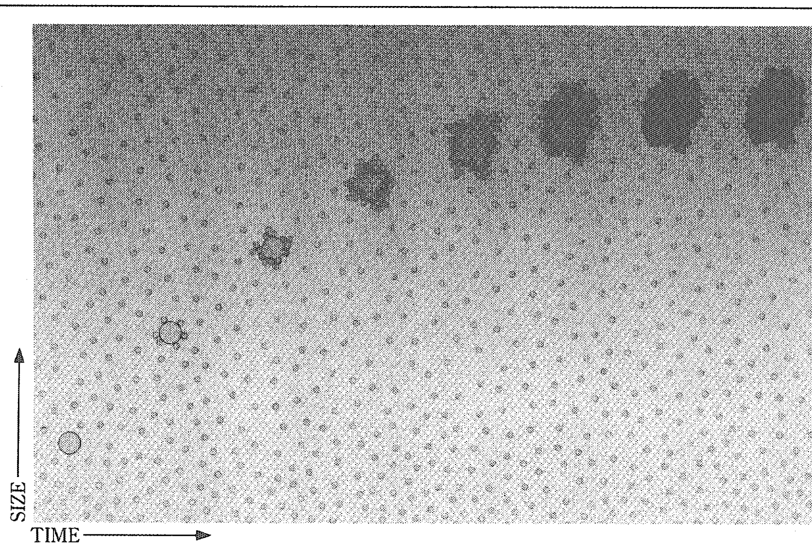


Figure 1: Total growth rate contrasted with growth rate per unit area plotted as a function of ethylene/oxygen mole ratio measured at a given height above the burner face.

Figure 2: Artist's rendition of the surface growth of a single soot particle by the incorporation of acetylene molecules.



SOOT FORMATION may be divided into two stages. Microscopic soot particles are generated in the "inception" stage. They reach full size in the "growth" stage, which accounts for more than 95% of their final mass. Most scientific exploration has concentrated on particle inception which, despite all the effort, remains unexplained. Dr. Stephen J. Harris, a physical chemist at the General Motors Research Laboratories, has reversed traditional priorities. Combining experiment with logic, he has formulated the first quantitative explanation of the growth stage in soot formation.

Dr. Harris arrived at his mechanism through an elaborate process of elimination. To focus on the chemistry of soot growth, he began by eliminating from his investigation the complexities introduced by turbulence and mixing. He limited his research to premixed, ethylene/oxygen, laminar flames with one-dimensional flow.

Previous descriptions in the literature told him that two processes take place simultaneously during growth. Incipient particles collide and coalesce into larger particles, while growing at the same time by incorporating hydrocarbon molecules from the burned gases.

The first process reduces total surface area without changing total mass, while the second, called "surface growth," increases both total surface area and total mass. Hence, the increase in the total mass of soot can be entirely attributed to surface growth.

Dr. Harris set out to identify the hydrocarbon molecules—or "growth species"—responsible for surface growth. Increasing by increments the richness of the flame, he made the key discovery that although the total mass growth rate (gm/sec) increases strongly when the ratio of ethylene to oxygen is increased, the mass growth rate per unit surface area (gm/cm^2/sec) increases only slightly (see Figure 1). Thus, the controlling variable for how much soot is formed is not the concentration of growth species, but the surface area available for growth.

This finding led him to conclude that richer flames produce more total soot because they generate more particles in the inception stage. More incipient particles offer greater initial surface area for the incorporation of hydrocarbons.

Since the growth rate per unit area must depend on growth species concentration, this concentration must be similar from flame to flame. Dr. Harris went on to reason that there must either be enough growth species at the outset to account for the total soot growth in the richest flame, or the species must be rapidly formed within the flame from another hydrocarbon present in high enough concentration.

HE NARROWED his search to the four most abundant classes of hydrocarbons found in flames: acetylene, polyacetylenes, polycyclic aromatic hydrocarbons (PAH), and methane. Methane can be eliminated, because its concentration does not decrease as soot is produced. There is not enough PAH to account for soot formation in any flame. Neither of these two hydrocarbons can be readily formed from the other major species present. That left only acetylene and the polyacetylenes.

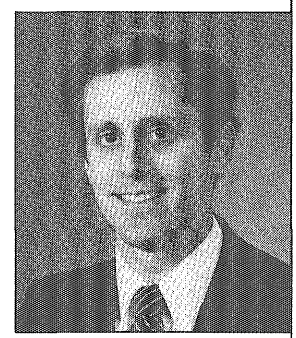
Acetylene contains enough hydrogen to account for the hydrogen content of soot measured in the early stages of growth. But among the polyacetylenes, only diacetylene could possibly supply enough hydrogen. That left acetylene and diacetylene.

There is more than enough acetylene to account for the mass of soot produced. There is not enough diacetylene, and while diacetylene can be formed from the abundant supply of acetylene, the reported rate of conversion is too slow for diacetylene to play a significant role. That left only acetylene.

Dr. Harris verified that acetylene is the growth species by determining that the slight increase in growth rate per unit area is proportional to the increase in acetylene concentration (see Figure 1). He also found that the rate constant he measured was in agreement with the reported rate constant for the decomposition of acetylene on carbon. These findings confirmed his hypothesis that soot particles grow in flames by the incorporation and subsequent decomposition of acetylene.

"Now that we know how soot grows," says Dr. Harris, "we can examine how it begins with greater understanding. Then, perhaps our knowledge will be complete enough to suggest better ways to reduce soot."

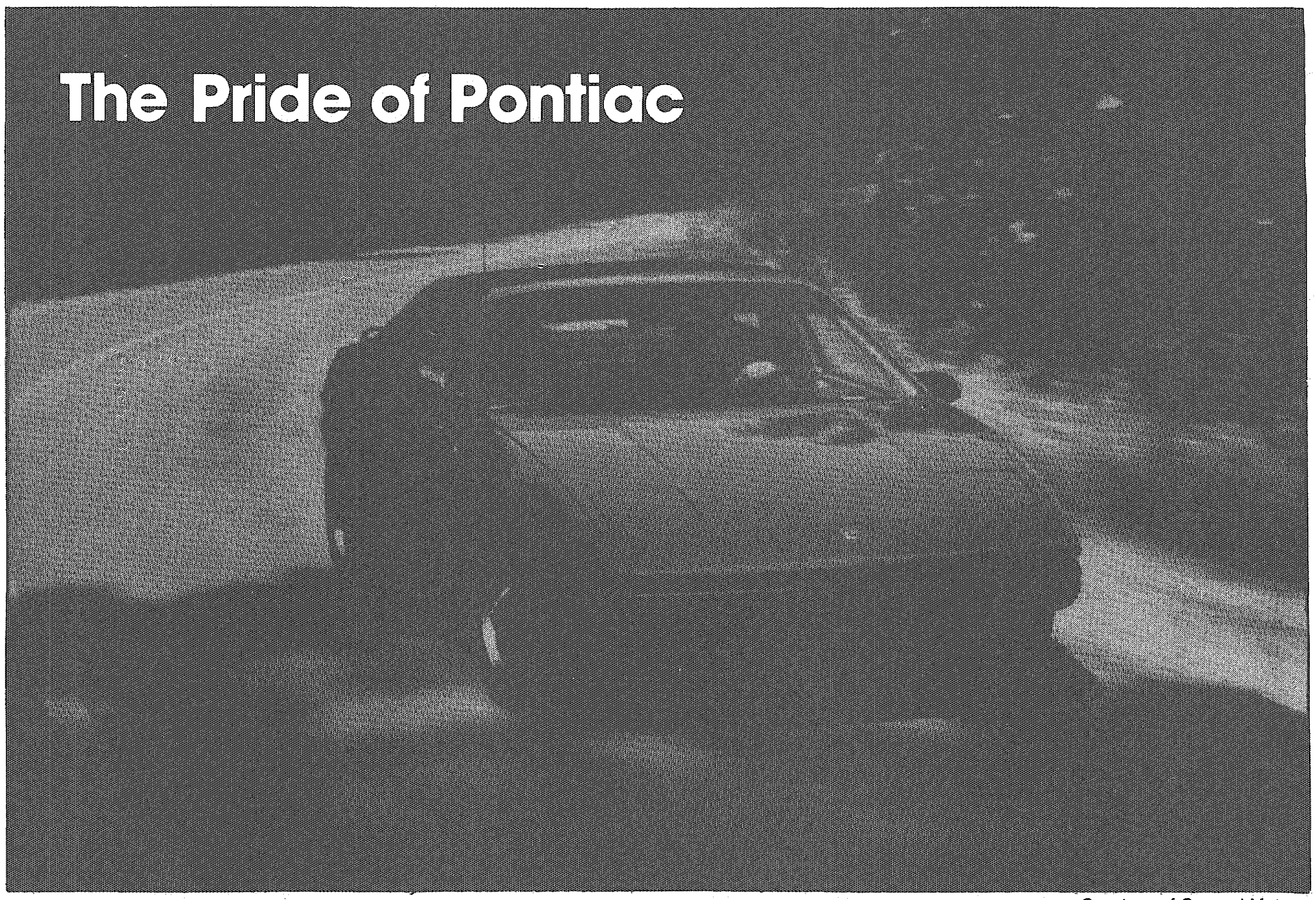
THE MAN BEHIND THE WORK



Dr. Stephen J. Harris is a Staff Research Chemist at the General Motors Research Laboratories. He is a member of the Physical Chemistry Department.

Dr. Harris graduated from UCLA in 1971. He received his Master's and Ph.D. degrees in physical chemistry from Harvard University. His doctoral thesis concerned Van der Waals forces between molecules. Following his Ph.D. in 1975, a Miller Institute Fellowship brought him back to the University of California, this time at Berkeley, where he spent two years studying laser-induced chemistry. He joined General Motors in 1977.

Dr. Harris conducted his investigation into soot particle growth with the aid of Senior Science Assistant Anita Weiner. His research interests at GM also include the use of laser diagnostic techniques in combustion analysis, with special emphasis on intracavity spectroscopy.



Courtesy of General Motors

The Pride of Pontiac

By John Leier

FIERO—proud, high-spirited, self-respecting...

This is how *Cassell's Third Edition Italian Dictionary* defines "Fiero," the name of the radically new car from Pontiac division of General Motors. The Fiero marks a major reversal in the battle between Japanese and American automobile manufacturers to build a better car. Score the Fiero as a definite victory for Pontiac in the ability to pioneer the use of new materials and new manufacturing processes in the production of a high quality car. Pontiac has many reasons to be proud of the Fiero.

The Fiero is the first American two-seater to incorporate a mid-engine design. This means that when you sit down and turn the key, you hear the engine start up behind you, not in front as in the vast majority of cars on the market today. The mid-engine set-up usually offers the best weight distribution in a car. The engine Pontiac chose to place in this unique place is the aging 2.5 liter (151 cubic inch) "iron duke" engine. This engine has been around in its basic form for many years, but modifications were made before it was put into the Fiero's engine compartment. As with most engines of late, the "iron duke" has kicked the carburetor habit; in its place is a version of electronic fuel injection known as throttle-body injection. Pontiac also reworked the engine's cylinder head to include "swirl-port" intake passages. These changes allow the compression ratio to be raised from its previous 8.2:1 to 9:1. However, overall horsepower and torque remain essentially the same—92 hp at 4000 rpm and 134 ft·lbs at 2800 rpm.

The Fiero also breaks new ground in body construction. All of the exterior panels on the car are molded from "Enduraflex" plastics. The majority of these panels, including the hood, headlight covers, roof, and rear deck lid, are formed from sheet-molded compound (SMC). SMC has been used in very limited applications on a few vehicles in the past, including the Chevrolet Corvette, but its use has been confined to areas where the surface finish could be disguised by the contours of its location. Pontiac, however, in conjunction with the Budd Plastics Company, developed a new type of SMC with no finish problems. Most of the other body panels on the car are made from reinforced reaction-injection-molded urethane (RRIM). RRIM is ideal for places subject to dents since it will give upon impact, then pop back out and regain its previous shape. RRIM is used on the door and fender areas. Several other miscellaneous plastic compounds are used in small areas throughout the car.

Plastic panels offer several substantial benefits over steel counterparts. It is much easier to obtain very close tolerances with plastics than with conventional stamped steel panels. Better repeatability of dimensions leads to better fit and finish on the final product. For most applications plastics are also much lighter, allowing significant reductions in the

Technolog Interviews Pontiac's Tom Kalush of the Fiero Project Group.

Technolog: How did the original concept of the Fiero develop, and what were the main objectives of the project?

Pontiac: The project started around 1978 with the idea of introducing a small car which would increase the corporate fuel economy average. We also wanted a small car which would appeal to Pontiac's enthusiast market.

Technolog: What do you consider the most important innovation on the Fiero?

Pontiac: I feel that there are several important innovations. One of them is the driveable chassis. This allows all major components to be tested before the finished panels are installed in place. It is then not necessary to dismantle a major portion of a car to fix a minor problem located in a remote location. The other important innovation on the car is the machining of the frame so that all body panels fit well. No other automaker has done anything like this before. Machining the space-frame after it is welded together eliminates problems due to welding distortions.

Technolog: Why did Pontiac choose the mid-engine design for the Fiero?

Pontiac: There were two main reasons that the mid-engine configuration was used. The first is that there is no way an engine would fit in the front on a car with such a low hood-line. Either a new engine would have to be developed special, or the car would have to be raised. Neither of these alternatives was attractive since there was no time to create a new engine, and we did not want to change the basic shape or height of the car. We then decided that we would have to place the engine in back. Doing this also improves the handling of the car. All other things equal, it is generally accepted that a mid-engine car will out-perform its front-engine counterpart.

Technolog: Are there more mid-engine cars coming from General Motors now that the Fiero has "broken the ice"?

Pontiac: I can't say for sure, but I believe that this is something which will generally be reserved for specialty cars. We at Pontiac hope that the Fiero remains America's only mid-engined car.

Technolog: What exactly is "swirl-port injection"?

Pontiac: Swirl-port injection is a way of injecting the fuel into the cylinder in a sort of tornado effect. The swirling of the fuel through the cylinder heads leads to better combustion and better fuel efficiency.

Technolog: Will plastic panels replace a significant portion of steel in the moderate volume market?

Pontiac: Well, I guess that depends on how you define "significant." Plastics are generally much more attractive to the automotive engineer because of their characteristics; however steel does have some benefits also. Among steel's primary benefits is its ability to be used in large volume production—say 400,000 cars/year. Plastics simply can't be used in that large of production. But plastics will replace a lot of steel in the 100,000 car/year range.

Technolog: How has the public accepted the car and how is it selling?

Pontiac: The public is buying every Fiero we make. It looks as though we will sell double what everyone here thought we would and about what I thought we could sell. Just to give you an idea of the problems we are having keeping the Fieros in supply at the dealers, one measurement of the amount of cars out in the marketplace which can be sold is referred to as the "days supply." Generally we like to have about a sixty day supply of autos at any one time. Right now we only have a seven day supply of Fieros. This means that at the rate they are selling, we would run out in seven days if we stopped producing. You can compare the seven day supply for the Fiero to our supplies of other cars. For example, our new Sunbird Turbo has been selling very well, but we have an eighty-seven day supply. We have about a sixty to seventy day supply for the Firebird and a thirty-three day supply for our Pontiac 6000. We are looking at producing about 110,000 to 120,000 cars/year for the next few years. We feel that this is about the saturation point for the market, and building more would also sacrifice quality, something we are not willing to do.

Technolog: What is the price range for the Fiero? From the absolute cheapest to the most expensive?

Pontiac: The lowest priced Fiero is around $8,000. This is not a stripped down version though. We do have several standard items which can be deleted if the buyer wishes. The Fiero with every option would cost about $13,000. This includes the sheepskin inserts in the seats, the trunk-mounted luggage rack, and the stereo speakers in the headrests of the seats.

Technolog: What changes can we expect to see on the Fiero in the next few years? Are you seriously considering a turbo? A 5-speed? Targa top?

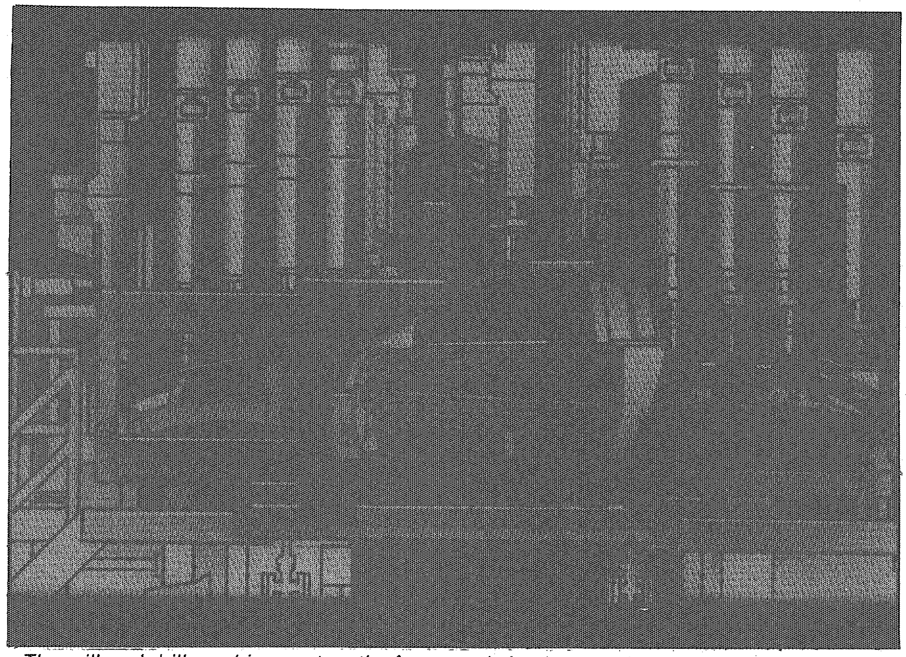
Pontiac: Pontiac does not have a turbocharging program for its existing engines. However I can tell you that the six-cylinder high-output Chevy engine which is currently used in the Camaro and Pontiac 6000STE will be offered next year in the Fiero. This engine should produce 0-60 times of around 8.5 seconds, very close to its competition and very good. As for the five-speed, we will be offering a five-speed transmission also. The current four-speed will be changed at first, and then a new transmission will be introduced which can handle the six-cylinder's extra torque. The targa top (removable top) will not be coming soon. There are some problems with removing the roof which have to be worked out first. But it is possible that sometime in the future you could see a targa. We have made a few for the auto shows and they have been accepted very well.

Continued on page 26

total weight of the car. Additionally, the body on the Fiero is expected to last three times as long as it would last if it were steel. This is primarily because there are absolutely no exterior body panels which can rust. Until recently most automotive manufacturers have disregarded these advantages, but the Fiero is making many think again. Honda just announced that it is playing catch-up with Pontiac by introducing plastic panels into its CRX coupe.

The switch to plastics was not without its problems, though. Pontiac had to develop a new paint technology since paint is absorbed into various materials differently. They developed a special primer to cover every panel first. The color is then applied, and on top of that is a special high-gloss top coat which equalizes the color differences. Besides developing better appearing plastics, the Pontiac design engineers needed to devise some way to hide the seams where different panels meet. This problem was solved by adding the black rub strip which traverses both sides of the car.

The plastics technology, however, is not the only revolutionary aspect of the body. Instead of using either a uni-frame construction or a body-and-frame construction, Pontiac engineers developed a "space-frame" for the car. The space-frame is similar to a roll cage on a race car in that it alone is designed to provide all of the strength for the car. The plastic body panels add absolutely no rigidness or strength; in fact, the car with all of its panels removed can pass government crash tests. The fact that the panels are not an integral part of the car means that they can be the last step in the assembly process. This reduces the chance that the finish of the car will be marred during the assembly. Conversely, a panel can be easily removed to be replaced or to allow easier access to electrical or mechanical components behind it.

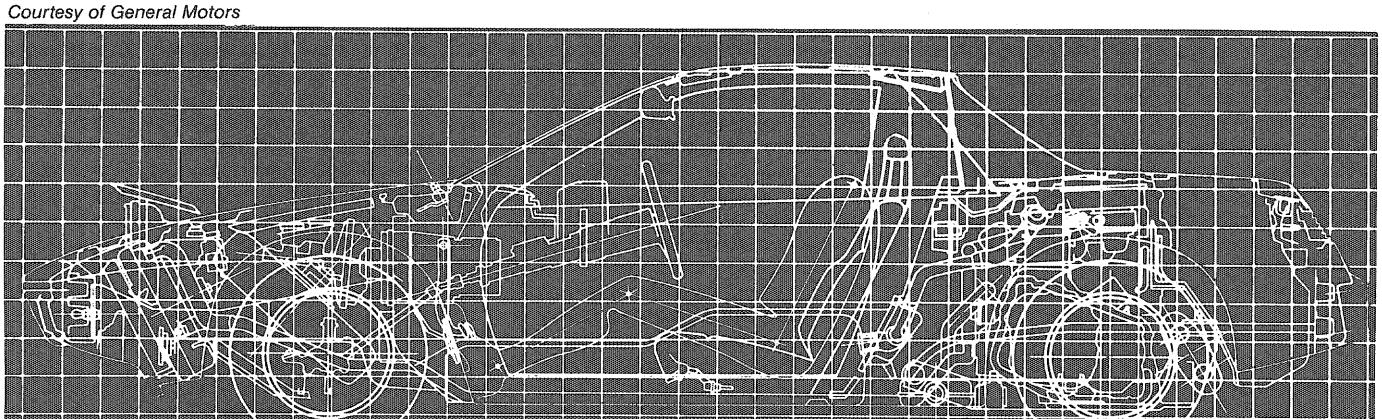


The mill-and drill machine centers the frame and simultaneously drills mounting holes in the 39 body-mounting pads. *Courtesy of General Motors*

The space-frame is constructed by welding together both high-strength and cold-rolled steel. Almost half of the welding is done by robots in a newly remodeled assembly plant in Pontiac, Michigan. However, even with robots, it is more difficult to maintain consistent tolerances with steel than with the plastic panels. Pontiac could have opted for the conventional method of placing shims between the frame and the panels, but instead it took a giant step forward in manufacturing quality. Pontiac engineers designed a machine which inspects each space-frame to determine its usability. Those not rejected are centered and secured within the mammoth two-story tall machine. The machine then mills and drills into 39 epoxy blocks simultaneously. These epoxy blocks, previously attached to the space-frame, become the mounting locations for the body panels after machining. Any variations in the space-frames are corrected in this way. Even though the distance between two blocks may differ from car to car, the distance between each hole in the blocks is uniform. Likewise, each is corrected to the proper depth. Thus body panels fit all cars uniformly, and a very good finish can be obtained. This method allows the gap between panels to be reduced from 0.125 in. to 0.015 in.

Continued on page 24

Courtesy of General Motors



The Graduate

By Jim Lundy

Higher Learning by Degrees

"Don't ask me that question. I don't want to think about it." A common response to a question heard with frightening frequency late in most academic years. Seniors, wary of those who would foist upon them the sad and well-worn truth that the "Real World" anxiously awaits their passage from the womb and into the cold outside, hide beneath stairways, in telephone booths, beyond secret trap doors, anywhere. A valiant effort often enough, though usually, sadly, in vain. For the question still remains: "What are you gonna do after graduation?"

After exploring the viable choices, a great many of the gathering horde opt for the seemingly friendly confines of Graduate School. What is offered here that cannot be found in the employment world? What are the drawbacks of engaging oneself in an advanced degree program? What possible reasons could anyone have for pursuing the life of a graduate student?

Becoming a graduate student can be a way of taking a time-out from life to ponder specific problems and topics which were merely glanced at in previous work. Curiosity killed the cat, and it also has a way of seducing aspiring young researchers seeking a tonic for the cerebral cortex. Marsha Combs, a geology graduate student, saw that "in my previous situation, intellectual stimulation was somewhat lacking. My biggest reason for returning to graduate school was to restore some of it." David Schwenke, chemistry graduate student, commented that "in my undergraduate work, we covered a lot of things that were sort of vaguely interesting, and I wanted to get better at some of them."

Many students have other motives in mind. Stuart Simmons, geology graduate student, asks "do you go to graduate school because you have this burning desire in your heart to learn something that you can't learn without the aid of some instructors to sort of pat you on the back and give you A's... or do you go to graduate school because you want a better paying job?" It is true that somewhat higher salaries often go to those with advanced degrees. Are the Halls of Higher Learning actually the Halls of Higher Earning?

Those interested in someday finding "research and development" jobs (including those in the academic field) know that although graduate school offers the chance to improve knowledge, it is also in the business of teaching research skills. Under the tutelage of often well-known authors and researchers, graduate students are often responsible for initial investigations, budget and grant proposals, setting up the problem, collecting information, searching and researching the literature, preparing illustrations, and drafting the final report or thesis. And, if lucky, the student is awarded more money to do it all again.

To be fair, probably few graduate students have eyes on the big dollar bill signs two or four years down the road. Many just want to end up with the sort of job that will interest them. "As far as business opportunities go, I'm from rural Washington State, and there were no immediate working opportunities..." says David. "... [graduate school] seemed like the next logical step.... It will certainly give me greater flexibility."

Stuart explains "... basically what I want to do is map rocks. I want to go out into the field and interpret the rocks. After my sophomore year at Macalester, I decided, 'Well, I can't get a job in this field without a Master's Degree.'"

Recent years have seen a rise in the number of applications to many graduate schools and departments, which can be attributed in part to the declining number of available jobs in many fields. As David puts it, "I didn't really feel up to leaving where I was, going to another city someplace and finding myself a job. I was a little hesitant; there was some trepidation in doing that. But when I thought of applying to graduate school, I could do that all by distance."

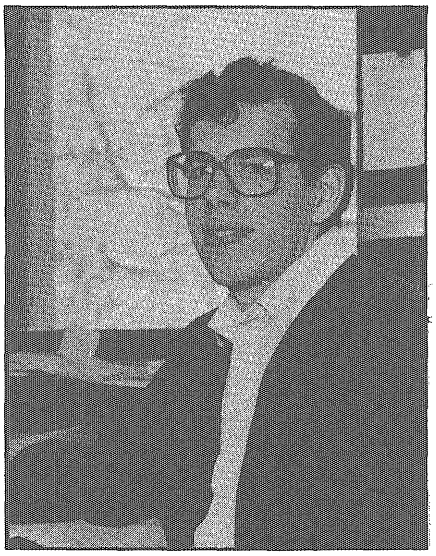
According to Stuart, "graduate school seemed easy to do. It seemed a lot easier to do than going out and getting a job." It can be a delay tactic, a way of doing something constructive while preparing the psyche for the inevitable leap into the working world outside.

But what is the true value of an advanced degree? Can it ensure employment? "When I go back to my country I will have to look hard for a job," says Ranbir Sinha, graduate student in mechanics. "But in the worst situation I could always start my own business." Many people in this country as well find that a graduate degree is in no way a job guarantee.

In fact, with the threat of overqualification ever looming in the distance, many find that a graduate degree can hinder job-hunting efforts. "Graduate students may have a hard time getting a more general kind of job if their interests change," observed Ranbir.

A more immediate point to consider is the cost involved in completing a graduate degree. High and still-climbing tuition costs discourage many potential students who cannot meet expenses on their own. Financial aid is usually available and helps a bit, but very few people ever make their first million while still a graduate student. Sacrifice is also required in terms of time (two to four years is a long time to be poor) and effort (the nine-to-five grind somehow doesn't sound so bad . . .). Additionally, the isolated environment of a university is not for everyone.

Graduate student David Schwenke.



"It's a closed world," says Stuart. "I don't think people should go to school if they don't first have some idea of what happens outside the holy walls and ivory towers. The thing to do is, when you come in, have some idea of the things you want to learn."

David agrees, adding that "one important choice is what you do your work in. A lot of people tend to look for what's paying the best now. That is, in my opinion, the wrong path to take because by the time you get out, things could have changed. Then you're stuck with [your major] and you weren't really interested in it in the first place."

It seems that the advantages and disadvantages of attending graduate school strike a precarious balance in the minds of those facing the choice. To misquote Shakespeare, the question is to go or not to go. Is what the "holy walls and ivory towers" offer worth the price in youth and riches? Or is it a deathwish? Perhaps those who live within the walls have a bit of Renaissance blood in their veins, the resolve to ignore the pleas of the hungry stomach for two or four or six years while the needs of the mind and heart are met. Is that too bold a statement? "There certainly are other things I could be doing," says David, with only the barest hint of regret in his eye. "Right now, though, this is what is interesting. . . ." ■

Initially **Jim Lundy,** a graduate student in geology, refused to write this story. He said the pay was peanuts. So we threw in a couple of carrot sticks and a bag of popcorn, and everything worked out.

Nuclear Summer from 15

town, he saw kids playing at recess in the school yard. He saw old Mrs. Henli blowing her whistle, trying to get the little rascals to behave. In front he saw the big yellow school bus. Mr. Houks, the janitor, also drove the bus, Charlie recalled. He wondered if Mr. Houks was working in the school now.

Off to his left he took in the business district. Broad Main Street sparkled in the warm sunshine. Charlie looked at the cars parked on the diagonal, lined up that way for two entire blocks. He saw a few shoppers pounding the sidewalk.

"There are probably a few farmer's wives," he thought, "come into town to get supplies." He smiled at the microcosm of American rural life that rested before his eyes. The town seemed to be wound up into the full swing of its regular daily activities.

Charlie couldn't stand to wait any longer. Eagerly, his eyes searched the closest neighborhood, looking for the white stucco house that had been his home since his marriage. He found it readily, and saw Alice, Megan, and Becca standing in the backyard waving. He squinted. They all had something in their hands. What was it? Flowers! Each one of them had a bouquet of flowers for him.

"I must have been gone a long time," he thought.

Anxiously, Charlie began to descend the hill toward his family. Alice, Becca, and Megan all left their backyard and ran toward him, flowers held out in front of them. Charlie could hardly believe it was true. Tears of joy began streaming down his face.

The grass seemed to get deeper and deeper as Charlie approached the bottom of the hill. He'd lost sight of his family.

Suddenly he saw Alice's face, brown eyes and bright smile, floating above the grass.

Charlie stopped. "Something's wrong," he thought. He looked at Alice, but her bright face betrayed no dismay.

"The grass!" Charlie shouted as he realized where he was supposed to be. "What happened to the dead zone?" he screamed.

Horrified, Charlie watched as the face he thought was his wife's began to twist and deform. The smiling brown eyes turned sad, and then turned hollow. Charlie was terrified to see the skeletal death-like face that his wife had worn in the government radiation sanitarium.

Fire shot out from the end of the creature's bouquet. Charlie felt a sudden sharp pain in his chest, and he gasped as he saw the devil holding a smoking gun. The fire in the devil's eyes shone brightly, then slowly faded as Charlie slumped forward to the ground.

The soldier looked at the prostrate man in the lead suit. "Must be another of those loonies trying to loot here in the dead zone," he said to his partner.

"As if there was anything worth stealing from this god-forsaken place," was the casual reply.

The sun quickly ducked behind the western horizon. ■

Jon Chaffee is a senior philosophy student. Let's hope his fiction remains fiction.

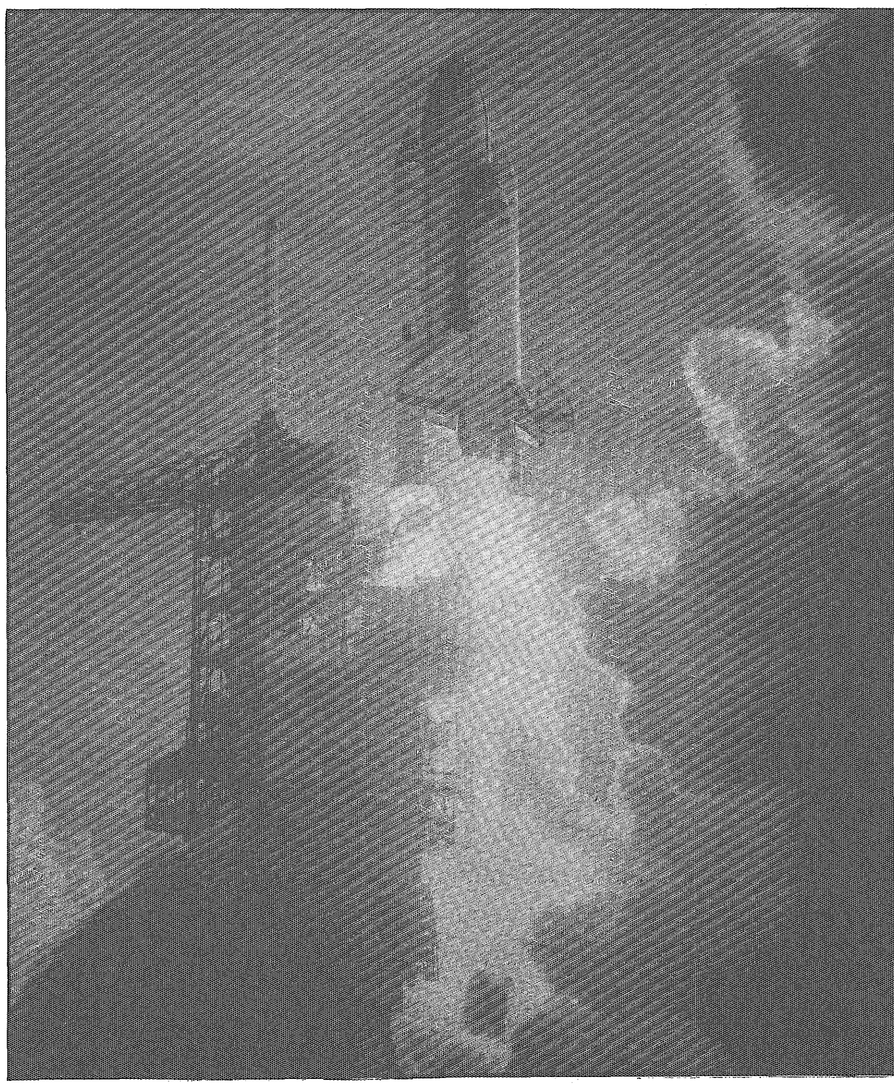
Ad Astra

By Scott Otterson

The Culture of Technology, Arnold Pacey, The MIT Press, hardcover, 210 pages.

If you are reading this magazine, you are probably involved in some sort of science or technology and because of that, at least four things can be said about you with reasonable certainty: you pride yourself on your rationality; performing technical or scientific work gives you personal satisfaction; you believe strongly that if a machine can be made better, then it should be made better; and you are probably male. These aspects are part of what **Arnold Pacey** calls the "culture of technology," and the way these attributes affect the judgment of scientists and engineers is the subject of his book named, appropriately enough, ***The Culture of Technology.***

On the surface, technology appears to be a value-free enterprise. For example, a technologist (to Pacey, either an applied scientist or engineer) might tell you that the space shuttle either works or it doesn't, and either way its function is determined by impersonal physical laws, independent of any wishy-washy human values. Technologists generally do not like moral ambiguity, and if they concentrate on the rational/physical aspect of a problem, they often believe the muddy water will go away. But should the shuttle have been built in the first place? When posed with this question a technologist will usually waffle around a bit, mumbling vaguely about the promise of spin-offs, future vaccines, or new alloys—pretty tenuous justifications for a project costing billions. When all these pseudo-technical rationalizations are stripped away, the technologist will finally admit that he believes the space shuttle is an end in itself, that it is part of "progress" and the "destiny of mankind," that if we can build it then we should. Ultimately, the shuttle is justified not by economic or scientific criteria but by its appeal to the technologist's sense of "virtuosity."



The space shuttle: a technological cathedral?

Pacey believes that since the beginning of the Industrial Revolution, virtuosity has been the real drive for technical and scientific progress. Industrialists, politicians and consumers, influenced by the technologists' arguments for "virtuous" technology, either enthusiastically endorse the latest

Continued on page 28

Pontiac from 20

Getting Corporate Approval

In the early 1980s, when General Motors (GM) was having a hard time selling the cars it had, it was, not surprisingly, difficult to get the corporate management to allocate money for a radical two-seater. However, Hulki Aldikacti, general manager of the Fiero project, and William Hoglund, general manager of Pontiac, were able to convince the big brass that there was room in the market for a two-seat, sporty, high-mileage car. Thus the original design goals were laid down. Had Elliot Estes not been president of GM at the time, it is questionable whether the project would have survived. Estes was a former general manager of Pontiac and had always wanted a low-priced alternative to the Corvette in the GM line.

And so after many delays the Fiero was finally given full approval. But Pontiac was only given $250 million to spend on the project. This meant that many parts from other cars had to be adapted and utilized. The front suspension was borrowed from the Chevy Chevette, and the rear drive-train was adapted from the GM X-cars.

Pontiac was able to combine all these parts to get its high-mileage commuter car (47 mpg highway estimated). Yet as gas prices stabilized, Pontiac decided to create another version of the Fiero. This version was named the Fiero SE and was intended to be a better handling, "funner" Fiero. This package can be ordered with a special suspension system and different gearing, among other things.

Both models were originally targeted at the younger age group, yet according to Pontiac salesmen, the cars seem to be selling well with all age groups. Anticipated annual sales were around 80,000 cars; based on recent sales, it appears that this estimate could be low. The Fiero seems to have found an untapped niche in the market, and Pontiac is making the most of it by keeping the price below $10,000 for the average model, thus keeping the car within the reach of many.

A Change in Attitude

One look at the production facility in Pontiac, Michigan, shows that the Pontiac people are serious about high quality for the Fiero. The barriers between management and workers have been eliminated to boost relations between the two. GM is also starting a program where employees get a chance to take home overnight a car which they have helped build. The idea is to get the workers to see their finished product and build pride in their work.

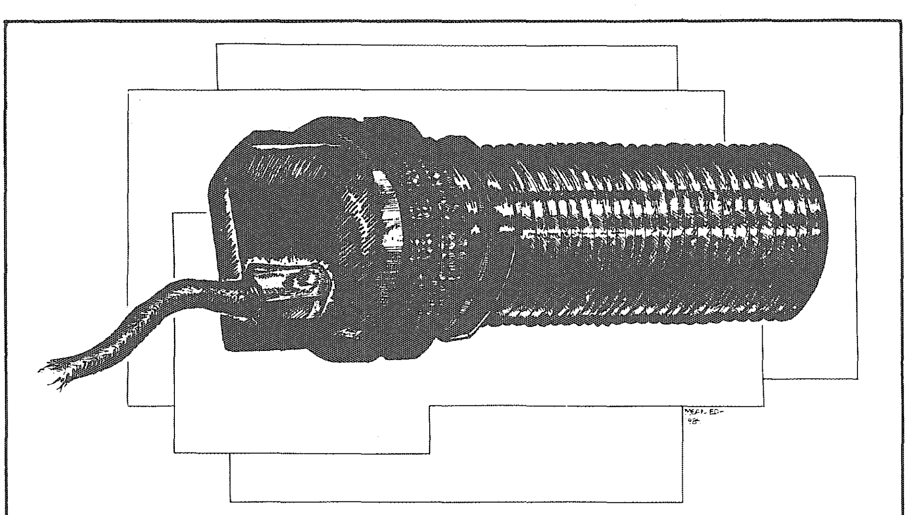
Pontiac is also stressing quality in the inventory it must purchase from outside suppliers. Gone are the days in which the least expensive bidder automatically received a contract. Pontiac is searching for companies which can supply quality parts at good prices. When a good supplier is found, it generally will get a contract for a cluster of inter-related products to make sure they all fit properly. Quality is also maintained by making sure suppliers use statistical control of their products.

Another new practice at Pontiac is the use of "just-in-time" inventory control. With this principle, only enough inventory for one day's assembly schedule is kept in the production plant. New deliveries are made each day, with most trucks and trains unloading at the location the parts will be used. A smaller inventory on hand means that it is easier to check for problems with the products. Pontiac also saves money by not buying excess inventory when it is not needed.

Pontiac is also involving the suppliers more actively in the engineering process. In the past an engineer would most likely have designed a part, then found a supplier to build it. Now the engineers and suppliers are working together to find the best way to design and build the products so that quality and low costs can be maintained. All of these steps may seem very logical, but they were not the normal practice until now.

After taking all of these steps to assure a superior product, Pontiac has begun to produce a car which can compete favorably with the best from Japan and Germany.

One of the thirty-nine mill-and drill spindles which machines the space frame.



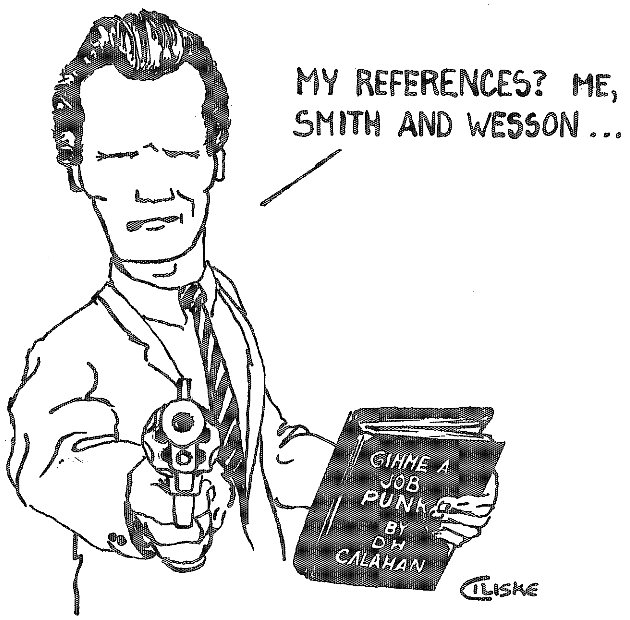
The Finished Product

After doing all the research for this story, I went to a Pontiac dealer to find out what the Fiero was really like. As far as I am concerned, Pontiac has a winner in the Fiero. The car is very roomy inside for a car so small outside. In fact, the amount of legroom is greater than in any car I have ever driven. When I was given a chance to see how it drives, I was surprised. Many car magazines would like you to believe that this car does not have enough power to carry two people and a six-pack of beer up a small hill. However I found that the Fiero has plenty of torque on the low end and will actually move away from a stop light at a fairly good rate. Since the gearing is primarily set for the low

Continued on page 26

Technotrivia ???

By L. Phillip Gravel III



CARL PRACTICES HIS NEW INTERVIEWING TECHNIQUE.

1. Minnesota has been called the "Land of 10,000 Lakes and 10,000,000 Potholes." Can you correctly complete this phrase: "Minnesota, Land of __________ Hazardous Waste Generators?"
2. This American inventor was born in 1847 and lived for 84 years. He had over 1,000 U.S. patents to his credit. What was his name? (Hint: His middle name was Alva.)
3. What star is closest to Earth, and what distance separates this star from Earth?
4. If you plan on taking your yacht down the Mississippi this spring, you should know the following: How deep is a fathom? How deep is mark twain?
5. Last winter, when a four-year-old boy spent over 20 minutes submerged in the icy waters of Lake Michigan, doctors used a relatively new technique known as "barbiturate coma" to save his life. What was used to create this drug-induced coma and thus prevent brain swelling and seizures?
6. What is the mean annual precipitation range for Minnesota?
7. Everyone knows that a minor error in any canning process which results in improper heat sterilization can allow the spore form of botulinum to survive. You probably also know that botulinum forms the toxin botulin, which is responsible for the dreaded form of food poisoning known as botulism. But, do you know how much botulin is required to kill one million guinea pigs?
8. What is the sum of the first eight digits of the ratio of a circle's circumference to its diameter?
9. This summer Grumman Aerospace Corporation will make the maiden flight of its radically new supersonic plane, the X-29. The plane utilizes the fact that at subsonic speeds the coefficient of drag increases with velocity, while beyond the sound barrier it decreases. What is the obvious design difference between the X-29 and most supersonic fighters?
10. Approximately how long does it take sunlight to reach the Earth?
11. How many pairs of chromosomes does a normal human have?
12. What is the outermost part of the sun's atmosphere called?
13. Who invented the mercury thermometer?

Trivia answers on page 28

Pontiac from 24

end, the car does not produce amazing 0 to 60 mph times, but they are respectable (about 11 seconds). The car cruises very well both on the freeway and on city streets. I was heading down University Avenue on the way back to the dealer trying to avoid potholes when I realized what fun this miniature slalom course can be with the right car. The car handles quite well, and when I finally looked down at the speedometer, I noticed I was going close to 50 mph. The car can be very deceiving concerning its speed.

The only problem with the car that I noticed is its poor shifter. I had a terrible time trying to get the car into first gear. I did learn that the car can be driven from a dead stop in third gear. The excellent stereo system with two speakers in each headrest can help one forget the car's faults, though.

Aside from the fact that this car could use a turbocharger, a five-speed, and a removable roof, it is a fine automobile. Pontiac has a car which is an exceptional bargain at $9,000. The styling of the car is much better than some cars costing over twice its price. Personally I would have a pair of Fieros in the driveway except that the University has already laid claim to most of my money for the next few years. Maybe we can get the I.T. Board of Publications to buy *Technolog* a staff car . . . ■

Specifications

Suspension: front: independent, unequal length control arms, coil springs, sway bar.
rear: independent, MacPherson strut, coil springs
Steering: Rack and pinion, 3.2 turns lock-to-lock, turning radius-39 ft.
Brakes: Four wheel disc brakes with aluminum calipers.
Dimensions: Wheelbase—93.4 in.
Length—160.7 in.
Height—46.9 in.
Width—68.9 in.
Weight—2,525 lbs.
EPA Fuel Economy: 26 mph (city)
Drive-train: mid-engine, rear drive, two door, two seater.
Engine: 2.5 liter in-line four, iron block and head, pushrods and hydraulic lifters. 9:1 compression ratio, throttle-body-injection.
Drive-train: 4-speed transmission, 4.10:1 final drive ratio, Gear ratios—3.53,1.95,1.24, 0.81.

John Leier, a junior mechanical and chemical engineering student, is also a budding young writer and an innovative thinker with incredible insight. Boy, what a super idea . . . a staff car, wow! . . .

Interview from 19

Technolog: Right now only red and white Fieros are available. What additional colors are coming, if any?

Pontiac: We just started producing a black Fiero, but it may not be available right away at the dealer. This is because of the way we run our painting operation. We will build only white Fieros for a few days, then change over to all black, etc. So we may only be making a few days' worth of black Fieros each week. So it takes longer for the black cars to appear on the showroom floor. We do have plans for production of silver cars in the future. Any other colors would be introduced only if one of these four was not used for a while.

Technolog: What differences will there be between the standard Fiero and the pace-car replicas you will be producing?

Pontiac: We can't put the actual engine used in the pace-car Fieros into the replicas since it is not certified. However the 2000 special edition Fieros being built will be noticeably different from other Fieros. The replicas will have a different front and rear fascia [the part of the car near the bumpers], and additionally, it will have a different rocker panel which connects these two fascias. This will give the Fiero a more aggressive look. Other changes include some interior parts, and special paint schemes and decals on the car.

Technolog: There has been some speculation that the reason the Fiero was delayed so many times is because Chevrolet put pressure on the corporation to kill the project. Is there any truth to this?

Pontiac: I think at first the Chevy people did not like the idea of Pontiac introducing a two-seat sports car. However after the project was defined more and they saw that it would not be directly competing with their Corvette, they were not so reluctant.

Technolog: With the success of the Fiero and the 6000STE, Pontiac seems to have changed its course. Where is Pontiac going in the future, and what type of cars can we expect to see from them?

Pontiac: In the past Pontiac typically produced average cars for average drivers. We decided that if Pontiac was going to survive, it was going to have to try to appeal to a certain type of person. We chose to aim our cars at the person who appreciates a well engineered car which has almost everything necessary for a "fun car." We are trying to sell to the person who doesn't mind paying a little extra for the little extras that come on the car. The four main cars that I see shaping Pontiac's future are the Fiero, which we intend to keep on the leading edge of technology, the Sunbird 2000, the Firebird and Firebird TransAm, and the 6000 and 6000STE. ■

TechnoFlog

By Stephen MacLennan
Al Hauser

A certain Indian chief had three squaws. He kept one in a tepee covered with deer hide, one in a tepee covered with buffalo hide, and one in a tepee covered with hippopotamus hide. In due time, the squaw in the deer hide tepee presented him with a son, as did the squaw in the buffalo hide tepee. However the squaw in the hippopotamus hide tepee presented the chief with twin sons.

Moral: The squaw in the hippopotamus is equal to the sum of the squaws in the other two hides.

Professor: "You missed my class yesterday, didn't you?"

Student: "No sir, not at all."

A person who claims that absolute zero is impossible to obtain hasn't taken a thermodynamics final yet.

The engineer just back from a hunting trip was describing the trip.

"Well, there was that big black bear hiding behind a tree. I realized that I only had one shot and that it had to be bounced off the canyon wall. Well, I calculated the angle of approach, the windage, and how much the bullet would deflect due to flattening after hitting the canyon wall."

Post-Euclidean Geometry

"Did you kill the bear?" asked his friends.

Replied the engineer, "No, I missed the wall."

"You look broken up. What's the matter?"

"I wrote home for money for a study lamp."

"So?"

"So, they sent me a study lamp."

Brain Teaser

There once existed a strange university in which the upperclassmen had radically different characters. The juniors, ever-bitter due to heavy course loads, always lie. The seniors, though still laden with several formidable classes, are heartened by graduation in the not-too-distant future, and hence always tell the truth.

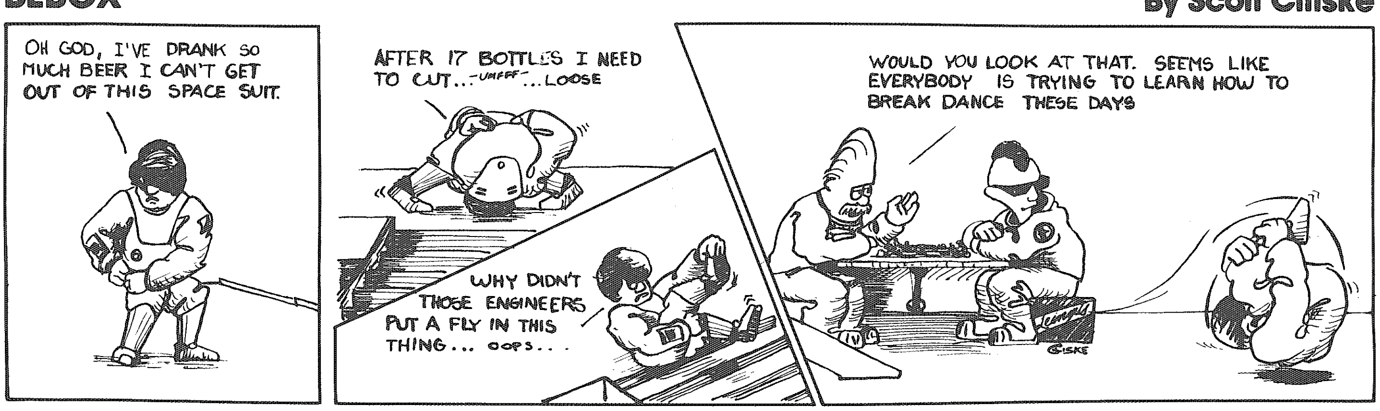
A very intelligent graduate student was introduced to three upperclassmen named Don, Jane and Mary. The graduate student asked each upperclassman one question:

Q: "Tell me, Don, is Jane a senior?"
A: "Yes."
Q: "Jane, do Don and Mary belong to the same class?"
A: "No."
Q: "Mary, what about Jane? Is she a senior?"
A: "Yes."

After hearing the answers, the graduate student smiled, knowing with supreme confidence to which class each undergraduate belonged. Which student(s) were juniors, and which were seniors?

Brain teaser solutions on page 28

BEBOX **By Scott Ciliske**



Brain Teaser Solution

Since Don and Mary answered the same question identically, they must be in the same class. Jane was thus lying when she said they were not in the same class, and so Jane is a junior. Since both Don and Mary said Jane was a senior, they also answered untruthfully. Therefore all three are juniors.

Technotrivia Answers

1. According to the Minnesota Waste Management Board's December 1983 Hazardous Waste Management Plan, the total number of hazardous waste generators is 1,926. Of these, 516 generate 96 percent of the 174,000 tons produced annually in the state.

2. Thomas Edison. Source: Joseph Kane, *Famous First Facts,* New York, H.C. Wilson Company, 1981.

3. The sun is the nearest star. It is approximately 5.89×10^{12} inches away. Source: Fourth grade science class.

4. A fathom is six feet, and mark twain is two fathoms deep. Source: *Webster's New Collegiate Dictionary,* 1980

5. The doctors gave the lad a massive dose of phenobarbital. Source: Matt Clark, "Drowned, But Still Alive," *Newsweek,* February 6, 1984.

6. The average precipitation is 20 to 30 inches, increasing from the northwest to the southeast. Source: *Hydrology for Engineers,* McGraw-Hill, New York, 1982.

7. Botulin is a very lethal poison. One milligram of botulin will kill approximately one million guinea pigs. Source: Thomas D. Brock, *Biology of Microorganisms,* Prentice-Hall, New Jersey, 1974.

8. 3+1+4+1+5+9+2+6=31.

9. The X-29 has its wings swept forward. It requires three computers making as many as 40 adjustments per second to remain stable at subsonic speeds. At supersonic speeds, however, this aircraft will be able to make dogfight maneuvers beyond the Wright brothers' wildest dreams. Source: Marbach and McAlevey, "The Shape of Planes to Come," *Newsweek,* December 5, 1983.

10. Eight minutes.

11. Humans have 23 pairs of chromosomes. Source: *Encyclopedia Britannica,* Volume 2, Chicago, 1974.

12. The corona. Source: *Webster's Dictionary.*

13. Gabriel Fahrenheit. Source: Ibid. Joseph Kane.

Ad Astra from 23

technical advances or become resigned to them as part of the inexorable march of progress. They build huge water projects, finance the most complicated jet fighters, buy home computers, snap up the flashiest cars with the most dazzling "hi-tech" instrument panels, and increase the budget for the space shuttle. But although technologists may have couched their arguments for or against a certain project in terms of economic, social, or military gains, their real motive for wanting to build or discover new things is simply the enjoyment they get out of having something done bigger or better than it has ever been done before.

Motives like these would be as valid as those of an artist who wants to create new art except that the costs to society of unjustifiable technology can be tremendous. Pacey lists examples: Technically impressive machines like the breeder reactor and the supersonic airliner Concorde have been built at tremendous expense only to prove economically or environmentally unsound. Western agricultural scientists have convinced Third World leaders to adopt biologically interesting but impractically energy-intensive "Green Revolution" solutions to their food shortages. Pacey even goes so far as to place part of the blame for the arms race squarely on the shoulders of the technologist. In the 1950s, although the United States was far ahead of the Soviets in terms of nuclear armaments, weapons scientists who wanted to further explore nuclear reactions pressured President Eisenhower to continue aggressive testing. The Soviets' resolve hardened, they became more paranoid, and they accelerated their own weapons programs. Realizing that a precious negotiating opportunity had been lost forever, Eisenhower, in his last address to the nation, warned against an all-powerful technical-scientific elite.

Pacey concedes that in the past the technologist's sense of virtuosity may have brought benefits commensurate with its cost, but in these times of world hunger, dwindling resources, factory automation, and the H-bomb (Robert Oppenheimer, a prominent nuclear scientist, once said that an invention used in the hydrogen bomb was "technically so sweet that you could not argue" against its adoption), we need to evaluate technical progress "for the sake of it" in terms of what it really is. If the space shuttle is mostly the modern equivalent of a cathedral, says Pacey, then its costs should be evaluated in that light.

This is something at which women should excel. Pacey scans the cultures of the world and comes to the conclusion that women in general do the tasks that serve human needs. They are the nurses, school teachers, child-raisers, and in cultures where there is no money to be made in raising food crops, they are the farmers. This is nothing new to the feminists, and although it grates on my nerves, I'll have to admit that they have a point. Pacey and the feminists agree that if more women were to enter the predominantly male domain of technology, technical priorities would shift from "cathedral building" to projects with human needs in mind.

The Culture of Technology is an unsettling book. Its well-written paragraphs lampoon much of what a technologist holds close to heart. It questions the value of a profession that is smug about its own worth. ("After all, who's more likely to get hired, a psych major or an engineer?") And although I can't completely agree with his thesis, Pacey makes a good case for the opinion that technologists largely build and explore for the fun of it—and then stick the rest of the world with the bill. ■

Technopuzzle

By Mark "Dr. Death" Stolzenburg
Dan "The Right-Hand Man" Rader
Al "The Hutt' Hauser

A long time ago, in a galaxy far, far away...

Many years have passed since the rebels successfully disposed of the evil Emperor. However it has now become known that the Emperor was only a puppet of the true lord of the galaxy, the despicable Darth Death. Once again Death rules the universe, striking terror in the hearts of innocent beings everywhere with his fleet of "Death" Stars. All appears lost.

And yet there is hope. In a dark and dingy corner of the universe (the basement of Mechanical Engineering) the rebel crew of the *Minnesota Technolog* works late into the night. Understaffed and low on supplies, the crew has just lost another member due to a calculus midquarter the following day. Still, morale remains high.

Listen:

"Ed, any luck with Death's latest crossword?"

"Cap'n, I canna break the laws of physics. I gotta have 15 minutes!"

"Ahh, Ed, you said that two weeks ago. If we don't decipher that puzzle by tomorrow, Darth Death will use us for Bantha fodder!"

"Aye, Cap'n. I'd like t' stick his lightsaber right into his ear..."

"Easy, Ed."

"...'n what er ya expect'n to do, Cap'n? We'll never solve this puzzle."

"I'm going to put out a call for help to every being in the universe, even the low-life forms."

"Ya mean even the foresters, Cap'n?"

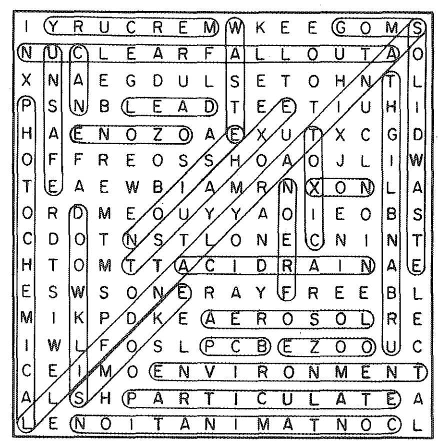
"Ed, there's a limit to everything."

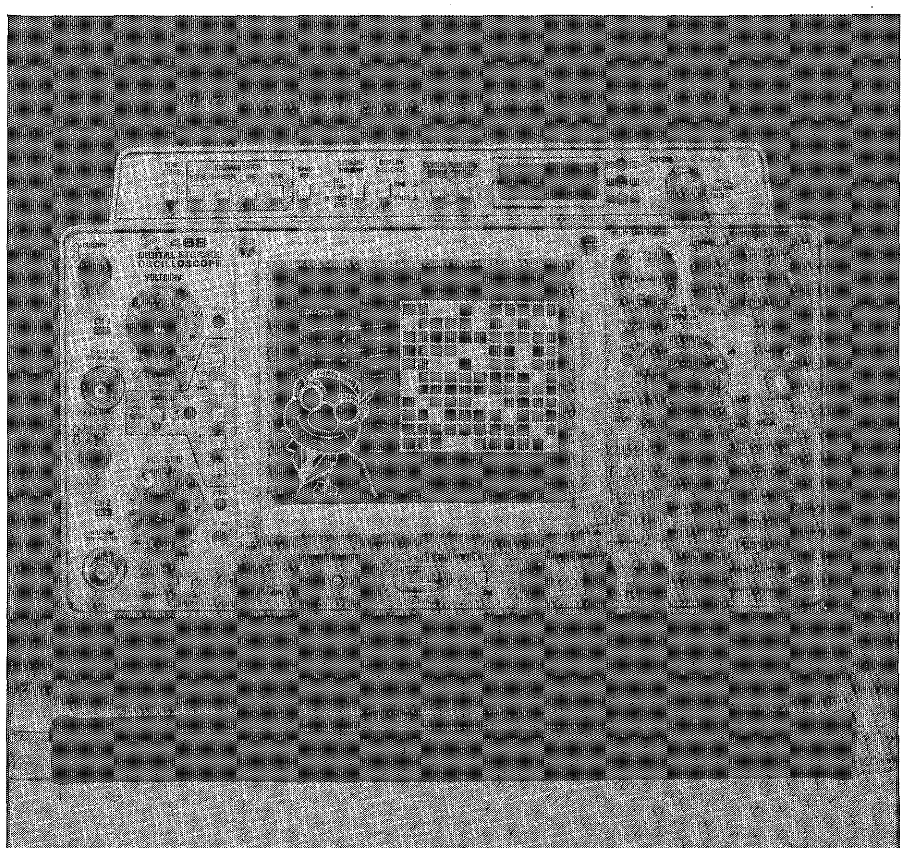
"Aye, Cap'n."

Will the students of I.T. be able to stop the all-powerful Darth Death? Or is the universe destined to spend eternity shrouded in darkness and fear? Last issue Dr. Death ran up against a formidable foe in Keith Alcock, a freshman electrical engineering student who successfully completed the word-search puzzle. Keith collected his just reward, a "Do I.T. with an Engineer" T-shirt. A similar fate awaits the first Jedi Knight to bring a correctly solved puzzle to Room #2, Mechanical Engineering. But hurry. Time is running out!

May the force be with you.

Winter 2 Technopuzzle solution (Only major words are shown.)





Mechanical Madness

Across

1. A form of mechanical work

9. ______ yield criterion

13. The last commandment

14. Every lugnut needs one.

16. Resistor/inductor circuit (abbr.)

17. A unit of acoustic power (abbr.)

18. Fortran relational operator

19. What Spot did

21. Motorcoolers

25. Essential to broomball play

26. Strength of the Earth's magnetic field

27. Engineer J. Carter's later occupation (abbr.)

28. New use of an old word

30. Trig. function

31. Panic button on terminal

32. Battleship which was nuked at Bikini Atoll

35. Portable sleeping machine

37. Section of town where Dr. Death dwells (abbr.)

38. USS __, battleship at Pearl Harbor (abbr.)

39. Example of rotary engine

43. Chicago luggage designator

44. Rusty four-bar linkage

47. Office of Electrical Engineers (abbr.)

48. Building next to Mechanical

49. Common response to an engineer's social advances

50. Named James 007

51. "Rolling" stop

54. Backwards 38

55. Primitive irrigation machine

59. Sheltered side

60. ____ 10W-30

61. Feminine sounding degree (abbr.)

62. Gas chromatograph (abbr.)

63. Unladled

Down

1. Student condition near finals

2. Shapes of car coils

3. Article

4. 1.8939×10^{-4} miles (abbr.)

5. Nonessential sounding transmission component

6. Time renowned for quality and good craftsmanship

7. Hungarian frustration

8. A metric ounce of prevention is worth a ______ of cure. (abbr.)

9. British vehicle

10. Home of John Deere and Cyrus McCormick (abbr.)

11. Fundamental materials relationship (abbr.)

12. Indicate when Klingons are approaching

15. A spot on a scope

20. Atomic number 18 (abbr.)

22. Repetitive events

23. Negative of positives (abbr.)

24. Noble sign

29. Correction to "We is engineers."

33. _____ manometer

34. Logical component of electronic machine

36. Beginnings of most machines

39. Logically deduced

40. Letter-shaped support structure

41. Ratted

42. Engine knocks

43. Fine

44. Related to a musical note or sound

45. "Can I use the car tonight?"

46. The letter "N"

52. Hardness index (abbr.)

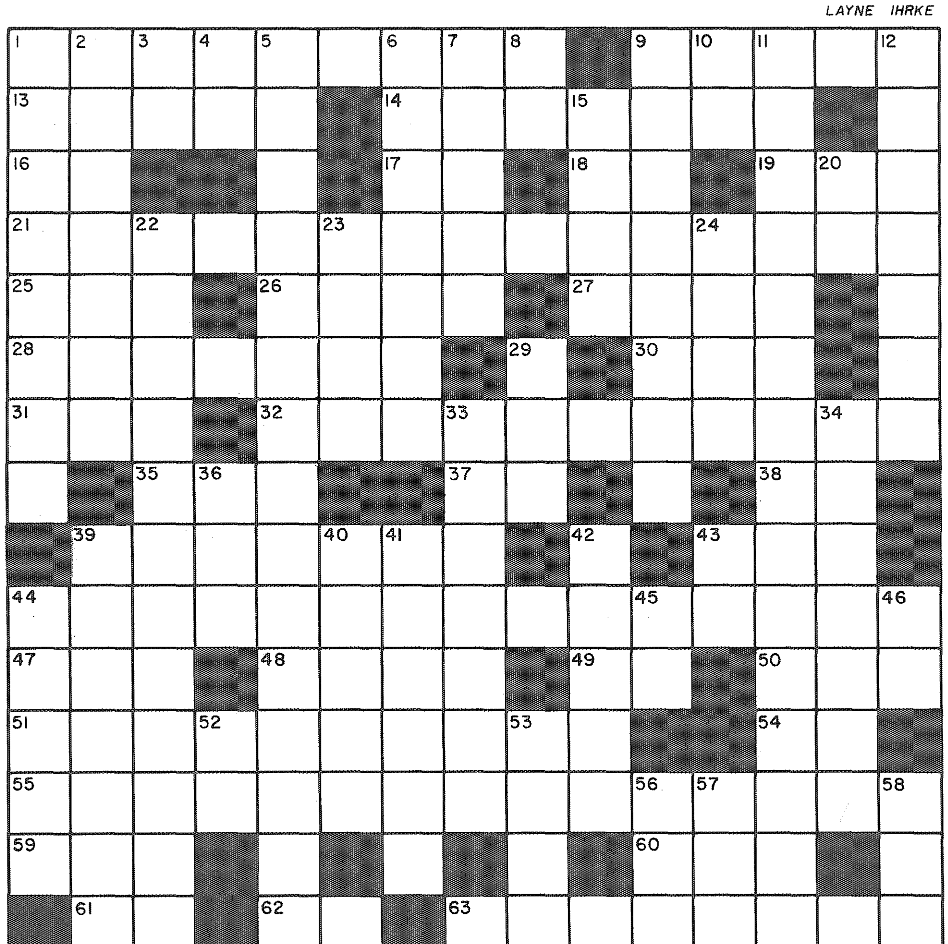
53. Clone of 24 down

56. FDR's now nearly bankrupt creation (abbr.)

57. -cam

58. Social equivalent of "weld"

LAYNE IHRKE



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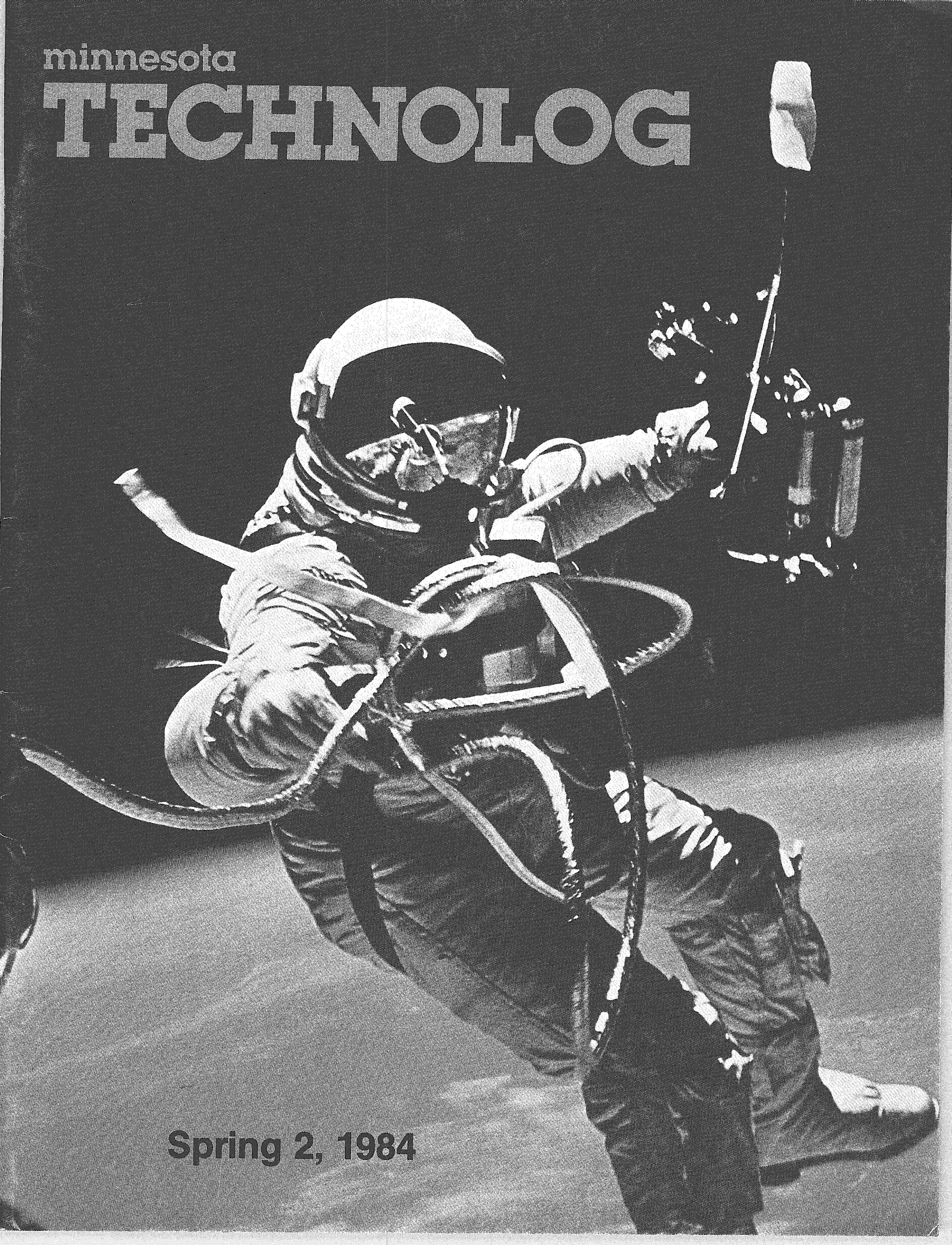
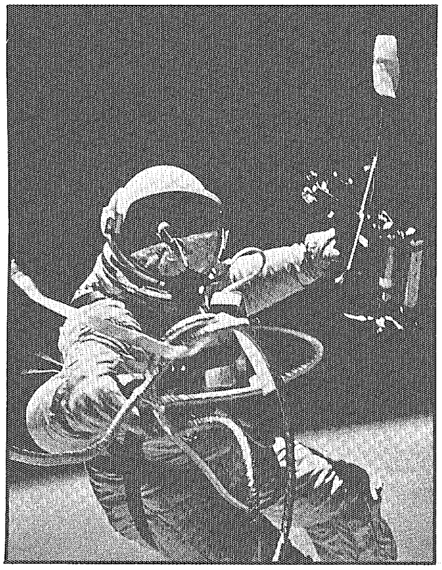


Spring 2, 1984



*During the historic 1965 Gemini 4 mission, Edward H. White became the first American to walk in space. Today, nearly 20 years later, man is taking the first steps towards manufacturing and living in space. In this issue, **Minnesota Technolog** examines mankind's future in space.*

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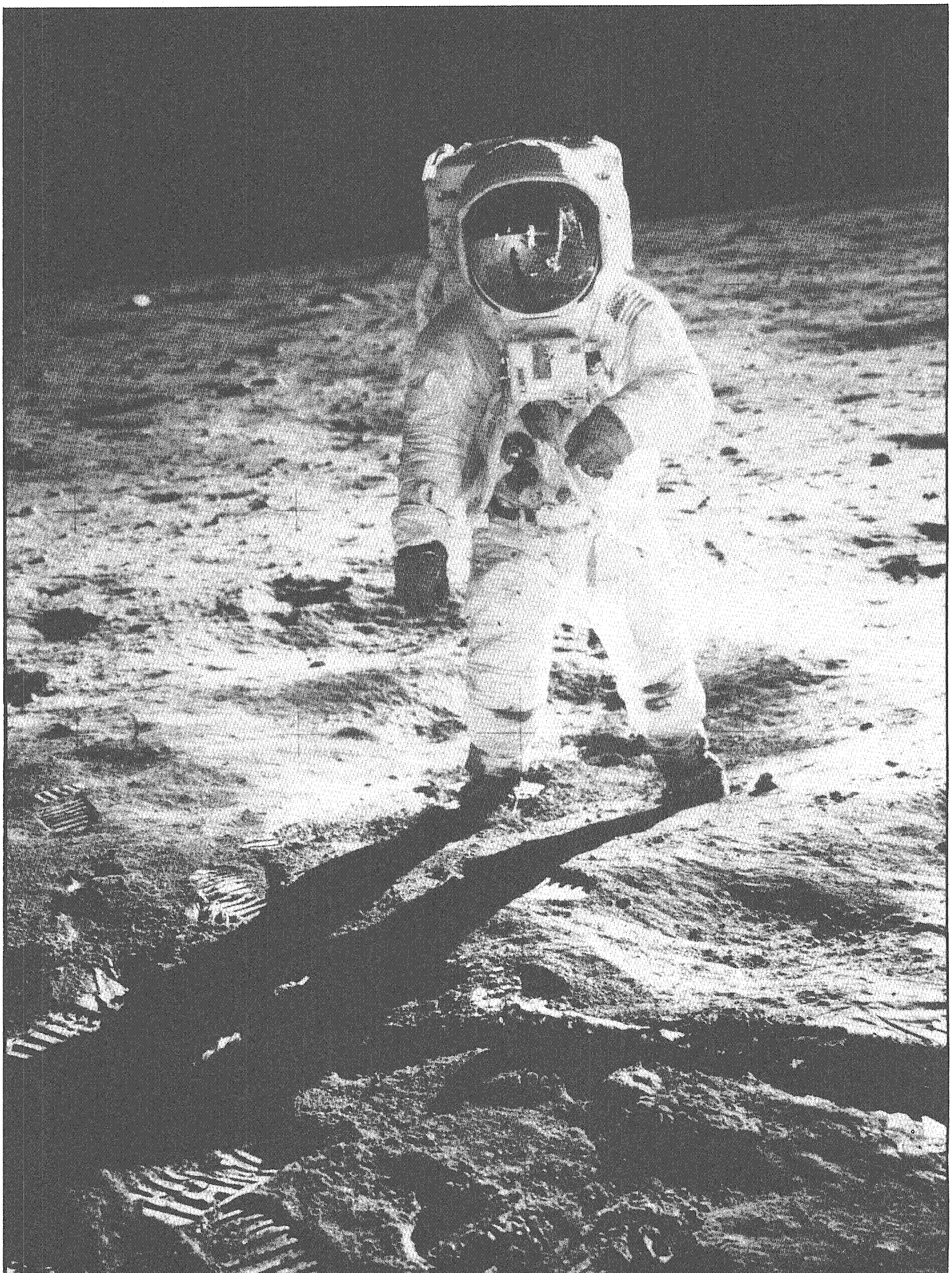


Courtesy of NASA

Editor's Log

The Two Faces of Technology

One of my friends recently remarked that he was excited about some of the features which the latest calculator models could boast, but at the same time, he was hesitant about certain problems these features caused. For example, the capability of storing a large number of equations and information allow these calculators to act as "crib notes" during closed-book exams, thus giving their owners an unfair advantage. Unless students are willing to regress to the use of slide rules, this problem defies an easy solution.

Unfortunately, this is only one small example of the two faces of technology. Although life is usually made easier by technology and broad new areas of study are opened for exploration, the gremlins of moral responsibility inevitably appear. A Pandora's box of questions must be answered due to technological advances which have made gene splicing, nuclear power, test tube babies, and our ability to more efficiently kill each other possible.

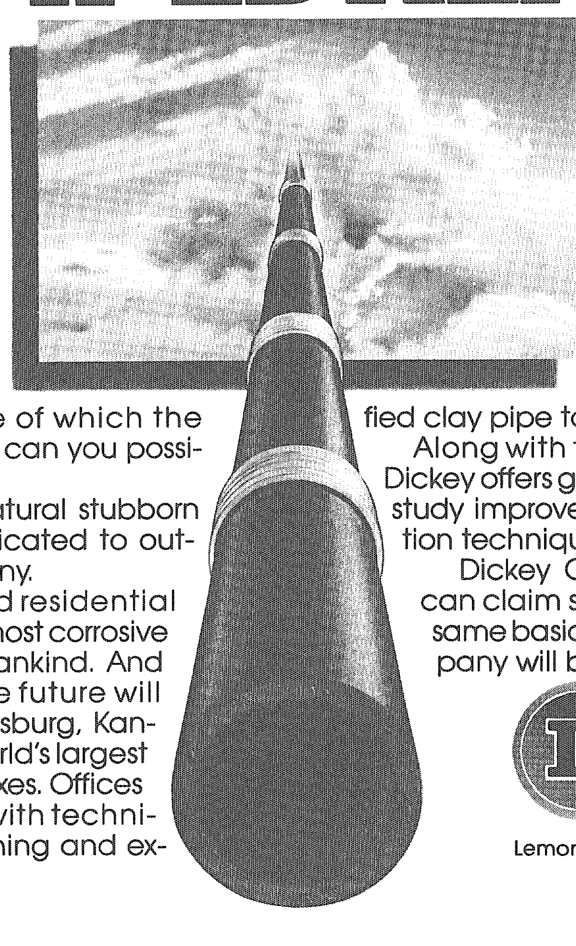
But who answers these questions? Engineers in the past have been fond of saying that they make the technology, but the politicians and corporate leaders make the decisions on how it is used and are morally responsible for the impact of the technology. The gas chambers of Nazi Germany and the verdicts of the Nuremberg trials would seem to suggest otherwise. Each individual *is* responsible for his or her actions. The implications of this are profound, especially for the engineer. As technology becomes a larger and more powerful part of everyone's life, the engineer finds himself holding—often reluctantly—a more and more powerful tool. Although engineers in all fields are faced with this question, those working for defense companies have been subjected to a great deal of criticism by public groups throughout the past few years. In this issue's "The Graduate" column, *Minnesota Technolog* examines the implications of moral responsibility on defense industry engineers. Individuals working for such companies were asked their opinions on the results of their labors, and others who protested these same companies were asked why they felt the way they did. The diversity of the reflections and conclusions obtained illustrates the complex nature of the moral issues involved in responsibly assessing the impact of one's labor. The blacks and whites of right and wrong are actually found to be varying shades of gray when carefully scrutinized. Today's tight job market often forces the graduating senior to take a close look at a job in which he or she otherwise would not be interested. A lone job offer often has a tendency to blur one's objectivity, making blacks and whites even grayer. Yet the difficulty and unpleasantness of the decision is not an excuse for ignoring it. That is why the increasing importance of technology in our lives and the larger number of moral questions facing today's engineers demand a required ethics course in the I.T. curriculum. The course would not be a moral code which students would memorize, for all decisions of this kind must come from within. Rather the course would ask questions and force students to think about the answers.

Already overworked and burdened with a large number of required courses, the I.T. student may not view this proposition favorably. Many I.T. students show signs of being allergic to nontechnical classes, just as many liberal arts students dread science courses. Unfortunately, this situation only emphasizes the need for such a course.

Before graduating, an engineer or science student will take well over 100 technical credits. It seems that four more credits dealing with the application of these 100 technical credits would be a wise investment. In fact, some schools already require that at least one ethics course be taken by all students, regardless of their field of study. But I.T. is not likely to do so without strong student support. It is hoped that students will realize the importance of such a course and urge the administration to take such a step. As Mark Paquette, a computer science student, said, "It is unethical *not* to have an ethics course."

Al Hauser
Editor

IMPROVING A PRODUCT THAT'S ALREADY GUARANTEED FOR 100 YEARS, IS NOT JUST A PIPEDREAM.



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Log Ledger

By Scott Dacko

• Nuclear Power Plants Now Number 293

At the end of 1983 there were 293 nuclear power plants operating in 24 countries, including 79 in the United States, according to a survey in the February 1984 issue of *Nuclear News.* Twenty-four units began operation during 1983, representing an increase of 18,913 megawatts (MW) of capacity. This brings the world's total nuclear capacity to 181,301 MW, up 8.6 percent over 1982. Seven units in the United States were cancelled during 1983. Despite the slowdown in the ordering of nuclear plants in many countries (the last United States order was in 1978), the heavy ordering of plants in the early 1970s will produce major increases in the next few years.

• 1984 Student Engineering Design Competition Announced

The James F. Lincoln Arc Welding Foundation is announcing its 1984 competition to recognize and reward engineering and technology students for solving design, engineering or fabricating problems involving the knowledge or application of arc welding. Separate awards are made to graduate and undergraduate students for papers submitted in either one of two divisions: structural or mechanical problems. For additional information write the James F. Lincoln Arc Welding Foundation, P.O. Box 17035, Cleveland, Ohio 44117-0035. The deadline is July 1, 1984.

The 1983-84 ***Minnesota Technolog*** *staff: First row: Kay Kirscht, Phillip Gravel, Scott Dacko, Second row: Roald Gundersen, Meribeth Nordloef, Scott Ciliski, Ed Wollack, Jeanne Etem, Third row: Mary Wilkosz, Karen Auguston, Jim Lundy, Forth row: Vernon Thorp, Mark Stolzenburg, Al Hauser, Layne Ihrke, Dan Rader. Not pictured: Greg Engel, Judith Friedman, Renee Kostner, Steve MacLennan, Scott Otterson, and Randy Smith-Kent.*

• *Technolog* Wins Awards

Minnesota Technolog upheld its reputation as one of the best publications of its kind during the 1984 Engineering College Magazines Associated Convention. This year's convention, hosted by Rensselaer Polytechnic Institute, was attended by 23 schools, including the University of California, the University of Wisconsin, Kansas State University, Louisiana Tech University, and Notre Dame. Awards were given in 13 categories. *Minnesota Technolog* won eight first place awards, including Best Cover (all issues), Best Art and Photography (all issues), Best Technical Story, Best Single Issue, and Best All Around Magazine, as well as a second place, a third place and an honorable mention award.

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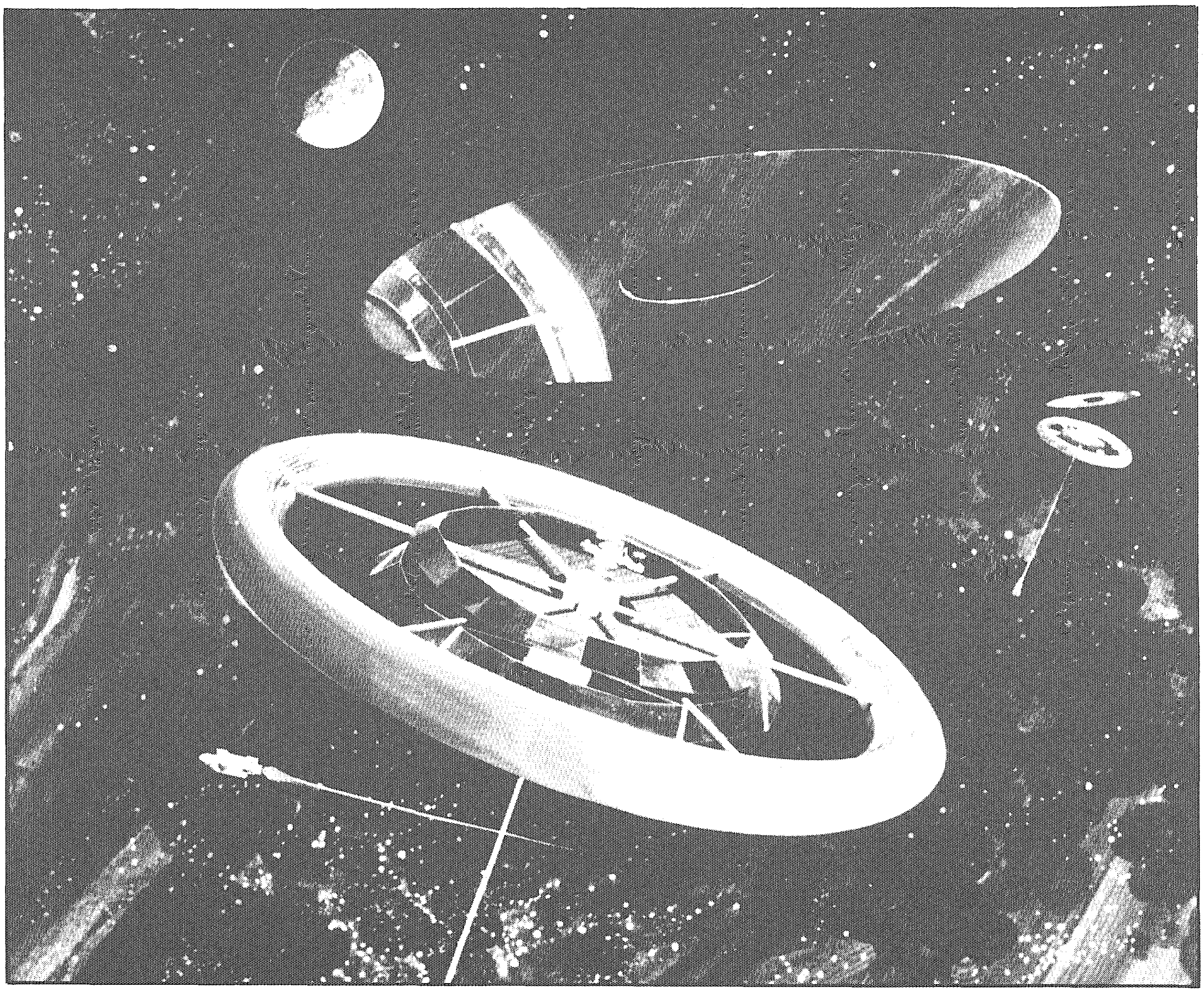


Space Colonization

By Lee Atchison

As man's dependence on outer space continues to grow, he finds it increasingly more important to develop his access to it. Space colonization can no longer be viewed as science fiction but as a real necessity for continued progress. A permanent manned enclosure would help to bridge the gap that exists between Earth and space and would make further development of space possible.

The idea of space colonization is not a new one. The idea first appeared in a book, published in 1869, called "Brick Moon," by Edward Everett Hale. In his story the first space colony was formed by accident. A brick sphere was to be catapulted into the Earth's orbit as a guide for maritime navigators. The sphere was accidentally catapulted into orbit before workers had a chance to leave it. Once in orbit the marooned workers, having an adequate amount of food and water, decided to remain on the sphere and live out their lives peacefully.

Today's society has advanced far beyond these ideas of space colonization. Space colonization is not only foreseeable but scientifically possible and economically feasible. Space habitats are no longer viewed as being a part of a science fiction classic but as a viable place to carry out the manufacture of crystals and medicines which require a space habitat and a place to build and repair communication and data retrieving satellites and construct solar power systems to reduce our demand on fossil fuels. Space habitats are viewed as a place for performing scientific experiments and building and using giant telescopes that can see without the obstruction of the Earth's atmosphere. As these and many other advantages become apparent, the feasibility and necessity of these stations will become more and more obvious.

The idea of a manned space station has already been explored. Skylab was man's earliest attempt at living for extended periods of time in space. It yielded a total of 513 man-days of study, experimentation, and research. Although there were problems, the overall mission was a success. The next step is a permanently manned space station—a "laboratory" in space where experimentation and research can be conducted. In his 1984 State of the Union Address, President Reagan officially announced that he will be directing NASA to "develop a permanently manned space station . . . within a decade." This station will "permit quantum leaps in our research in science, communications, in metals, and life saving medicines." The station will be manned by rotating crews of astronauts and scientists performing research in these various fields.

The idea of a space settlement goes far beyond the idea of this space station. It is the formation of a colony where people can live in a self-supporting community. Hundreds or thousands of people would work, live, raise families and carry out otherwise normal lives. The settlement would provide a comfortable living environment that would simulate, as closely as possible, a living environment on Earth while still allowing easy access to the many beneficial aspects of space, including weightlessness.

Much of the recent developments in space colonization research is credited to Professor Gerard O'Neill. In 1974 he published a report which appeared in *Physics Today* entitled "The Colonization of Space." In it he raised questions as to the feasibility of space settlements. As a result he received thousands of letters from scientists and physicists all over the world interested in the prospect. This started a worldwide movement to study the potential of space colonies. This storm of interest occurred when NASA officials were dismayed by the general public's loss of interest in space after the Apollo moon landings.

NASA, prompted by this enthusiasm, funded a study performed by the Ames Research Center and Stanford University. The study, conducted in the summer of 1975, discussed the feasibility of living in space. The report concentrated heavily on human needs in space and the psychological and physiological

The structure on which the study based its conclusions is a settlement of approximately 10,000 colonists. The colony would be held in a position equidistant from the Earth and the moon at a point called the Lagrangian liberation point, or L5. At this point there exists a shallow gravity well where the colony could remain indefinitely without being drawn towards either the Earth or the moon.

Several colony designs were discussed; the design chosen was a torus-shaped (doughnut-shaped) habitat with six spokes attached to a center hub. The center hub would contain docking facilities, communication facilities, and support equipment. The habitat would rotate to create artificial gravity in the outside rim of the torus, where the colonists would make their homes. Experiments that must be conducted in a zero-gravity environment would be conducted either in the hub, or in a laboratory hung below the colony. Above the colony would be a large mirror which would reflect light down to the colony, where a series of mirror baffles would allow the penetration of light while blocking other radiation. The colony would be fairly self-supporting but in the long run would require trade from Earth.

There are many factors to consider in the design and construction of a space habitat. However some of the most important and least understood factors concern the effects of living in space on humans. Both the physiological and psychological effects of space living can cause an increase in environmental stress leading to both physical and mental problems. To reduce stress, the station would be designed to have an environment as similar as possible to the Earth's, while still being practical to construct and maintain.

Pseudogravity

To maintain an environment similar to the Earth's, artificial gravity is necessary. Although a large experimental sample from which to draw conclusions is not available (less than 150 astronauts/cosmonauts have flown in space), the effects of weightlessness on the human body appears to be extensive. An increase in heart rate and reduction in blood pressure have been noticed during long exposures to weightlessness. Post-flight testing has shown a decrease in body water and a marked decrease in plasma volume. A decrease in muscle strength has also been noticed. These effects have

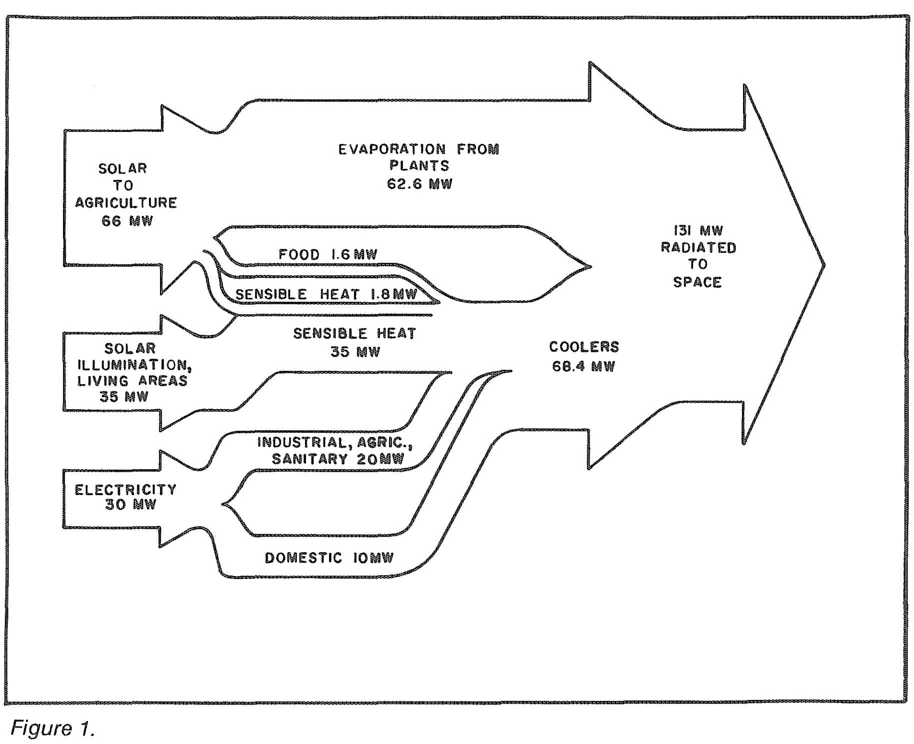


Figure 1.

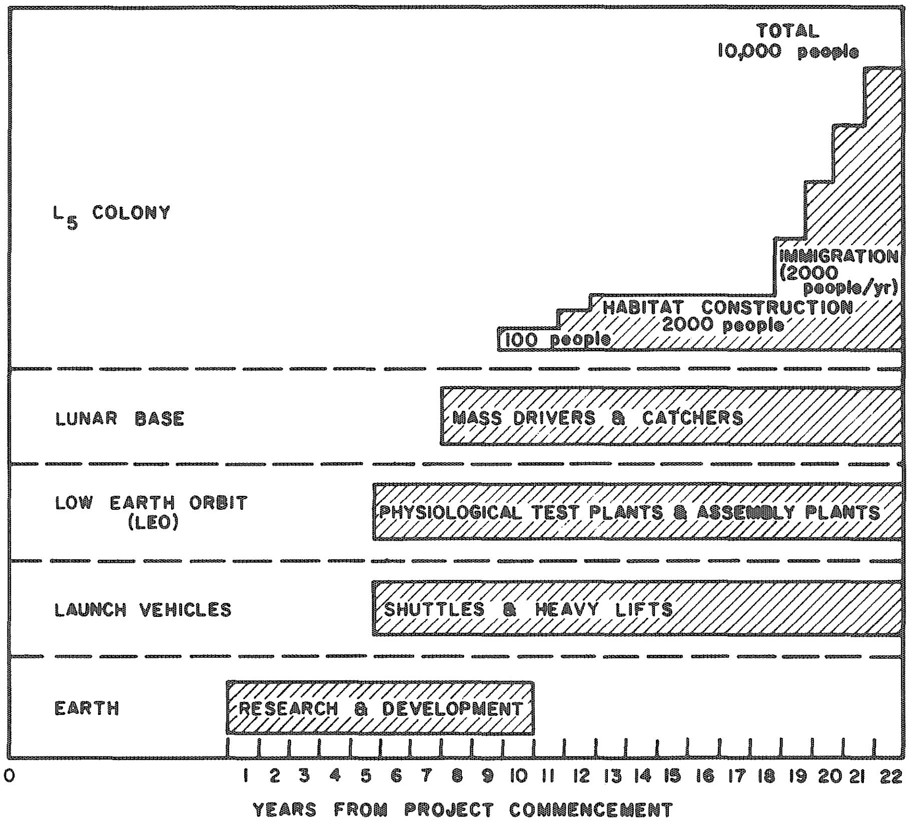


Figure 2.

been noticed in the relatively short-term exposures of the past space flights. No one knows how detrimental a permanent exposure to weightlessness will be to humans. Therefore, it has been assumed that a gravity similar to Earth's is necessary.

The obvious method of creating artificial gravity is to use a rotating station. In the case of the torus design, artificial gravity is created along the outside rim of the structure. By varying the speed of rotation, the force of gravity can be varied. A ten percent variation in the gravitational force from that of the Earth is considered safe.

A rotating environment creates other problems, however. One effect, known as the "Coriolis force," is an added force which supplies a "sideways" force upon one's inner ear whenever one moves. This force will result in dizziness and motion sickness. To reduce the effect of the Coriolis force, a slow rotational speed is necessary. Speeds in excess of a few revolutions per minute are considered unsafe.

Atmosphere

In order for humans to live, an atmosphere is needed; oxygen is necessary for humans to breathe. A large deviation from the amount of oxygen on Earth should be avoided. The partial pressure of oxygen (pO_2) is about 22.7 kiloPascals (kPa). Nitrogen is necessary for many plants to survive and should also be included. However, it can appear at a significantly lower concentration than it does on Earth (it constitutes 80 percent of Earth's atmosphere). A figure of 26.7 kPa is approximately correct. Carbon dioxide is also needed for plant photosynthesis but should be maintained at a low level because it will tend to be created naturally by human respiration. To live comfortably, man also requires a moderate relative humidity and temperature. However, the range of these values can vary significantly. Overall, it should be noted that the amount of atmosphere can be markedly lower than that of Earth. As long as the oxygen concentration is maintained at a relatively high level, normal amounts of human activity can be achieved. The primary advantage of a reduced atmospheric pressure is that a lower structural strength is necessary in the station.

Energy

Energy is of prime importance to the colony. To be self-supporting, the colony must find not only efficient ways to take in energy but adequate ways of dissipating it. The most logical source of energy is from the sun. Unobstructed by the Earth's atmosphere, solar energy can adequately meet the energy needs of the colony.

For the colony designed in the NASA study, 131 megawatts (MW) of power would be necessary to maintain the system. Figure 1 shows how the energy would be used in the colony. The energy intake on the left corresponds to both direct solar energy for heating and illumination and also electricity generated by large solar cell arrays. On the right is energy that must be dissipated to outer space to cool the colony and maintain the energy balance. This dissipation must be accomplished by large radiators. To dissipate 131 MW of power, 630,000 square meters of radiators must be supplied. This corresponds to a disk one kilometer in diameter. It is just as important to dissipate this energy as it is to obtain the energy in the first place.

The question remains, how long will it be before a space colony of this magnitude is built? Much research must be performed before a venture of this size can be attempted. The following are necessary steps to achieve the development of the first space colony:

1. Establish an orbiting space station, similar to Skylab but larger in proportion, to further test the long term effects of living in space on man.
2. Develop a heavy payload launch system for bringing large amounts of material into space inexpensively. This is needed early to facilitate the transfer of building materials and workers. After the colony is constructed, it will be used for trade and passenger transportation.
3. Develop a solar power system (SPS) to meet energy needs in space. These will also be used to inexpensively beam energy to Earth.
4. Establish a lunar base to explore and possibly mine the mineral wealth of the moon. This is necessary because it is more economical to bring material from the moon to space than it is from Earth to space.
5. Further develop the transportation systems from Earth to low Earth orbit (LEO), the Moon, lunar orbit, and the colony point at L5.

Figure 2 shows the time scale necessary for the previous steps. It covers the time from when the commitment to development first begins to the time the immigration to the first colony is complete. The total time elapsed is estimated to be 22

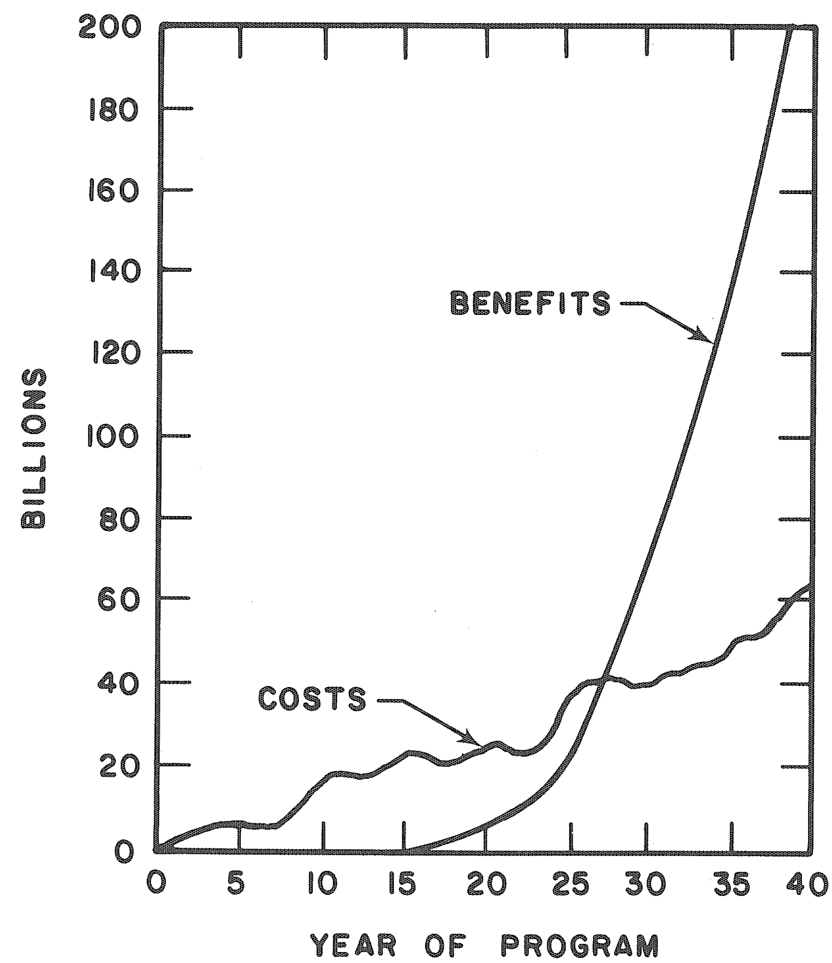
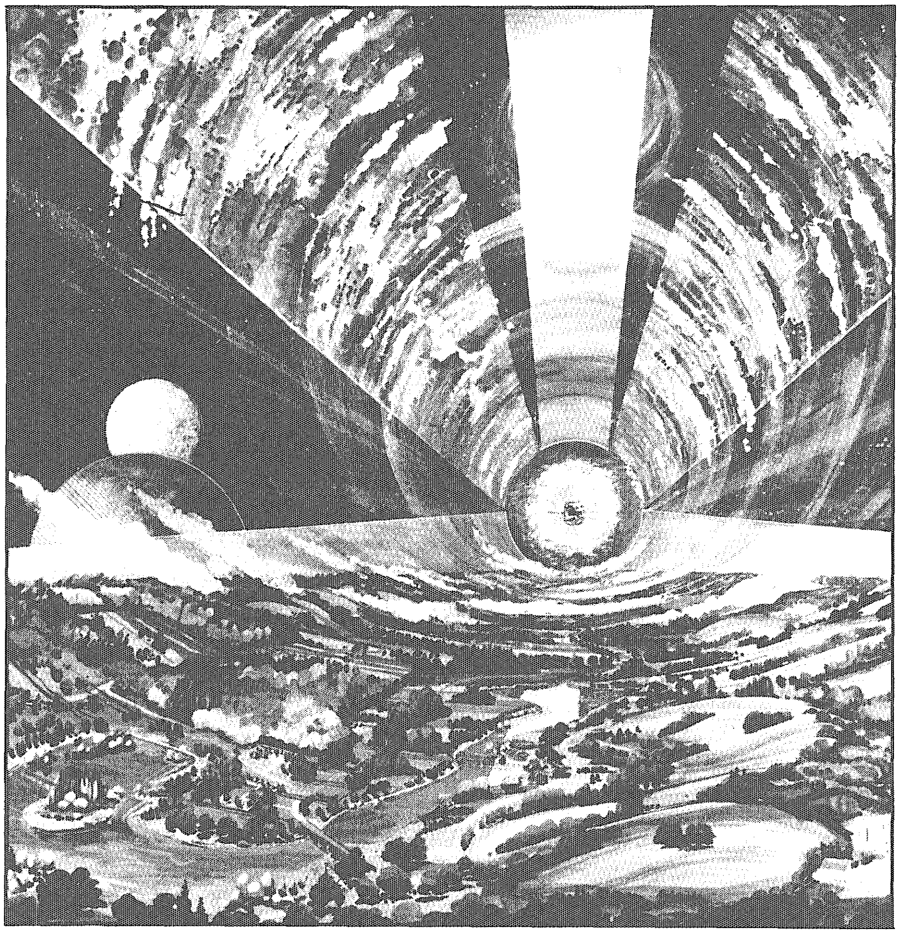


Figure 3.



years.

The break-even point from which the colonization of space will start paying for itself (bringing in more revenue than that spent in construction, maintenance, and research), is 28 years (see figure 3). After 45 years the colony could bring in an estimated $304 billion dollars while only costing $74 billion dollars. These figures are based on the 1975 NASA study. Most of the income, it was assumed, will be generated from SPS systems beaming energy to Earth.

This is only the tip of the iceberg. The long term effects of space colonization can be, at best, guessed. Much research is necessary to explore all aspects of living in space. This research must be conducted before any serious colony designing can be done. Many people have predicted that the first lunar mining base will be constructed early in the 21st century and large space colonies by the year 2100. Even though this is far in the future, continued research is necessary if the idea of space colonization will someday no longer be science fiction, but science fact. ■

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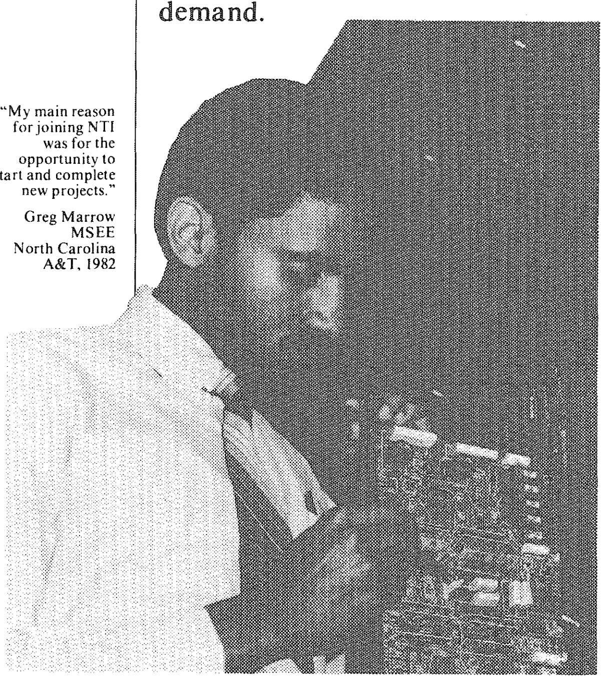

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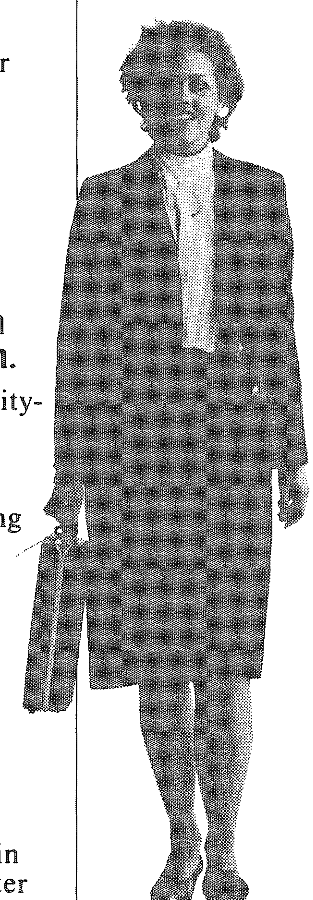

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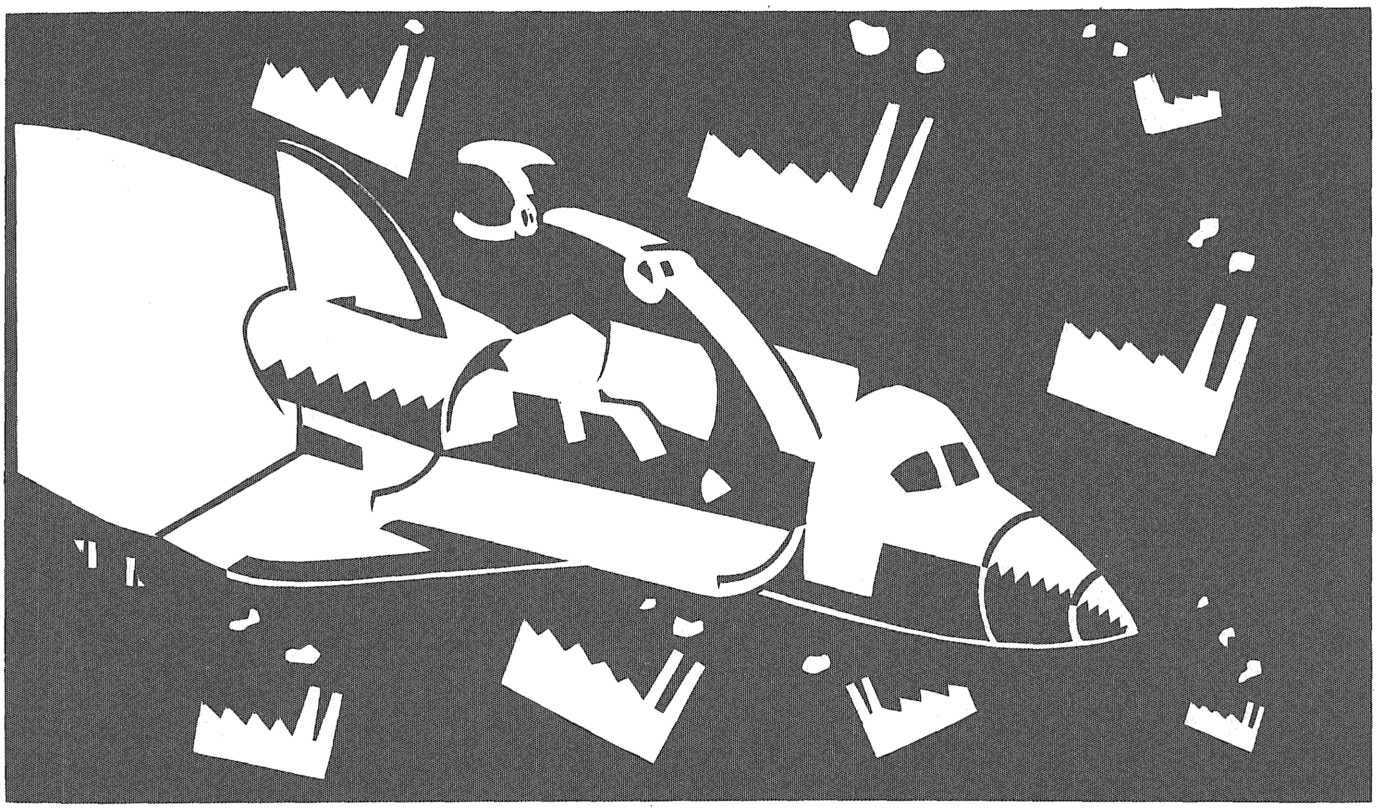


Factories in Space

By Wayne Whitwam

Spinoffs of products developed for use during spaceflight have seen many practical pplications. Everything from water purifiers to space food sticks, once developed for use by astronauts, are now commonly found in the home. Soon, however, industry plans to take a different turn; products will be made not *for* spaceflight, but rather *during* spaceflight. Before the turn of the century, store shelves will be lined with goods labeled "Made in Space." Everything in the household, from razor blades to kitchen blenders, will be made from alloys harder than diamond. Previously priceless medicines will be commonly available, and cures for hemophelia, diabetes, and cancer will be right around the corner. Foam metal will float on water. Priceless gems, surpassing in size any found on the planet, will be readily grown in space. Indeed, the world that futurists, writers, and scientists merely dream about—a fantastic comic book world—now appears within reach, all because of space manufacturing.

Granted, the idea of materials processing in space is nothing new. Officials at the National Aeronautics and Space Administration (NASA) have emphasized for years that the space shuttle would carry prototype manufacturing plants, allowing scientists to reuse materials processing devices and even take part in the orbital experiments.

However, the fervor behind orbital industry has just begun; NASA plans to orbit a permanently manned space station by 1992. Although much work still remains before any launch date, private enterprise is fighting its way to get on board. Companies such as 3M, McDonnell-Douglas, Johnson & Johnson, John Deere, and others have made reservations in a joint endeavor program with NASA. Many more are soon to follow. Each firm plans to have its own lab space on the station as an ongoing microgravity/microvacuum research facility. NASA just pays for the trip.

"It's exciting to be involved in the project," says 3M Research Physicist William Egbert. "A lot of people within 3M have ideas, with specific things they'd like to try. No sooner had we announced our agreement, when these people were beating down our doors. It was almost a stampede."

Since the conceptual years of orbital flight, scientists have simulated on Earth many of the harsh environmental factors encountered in space—such as extreme cold, the absence of atmosphere, and intense radiation from the sun and other sources. Try as they might, they found that approximating microgravity for any length of time on Earth was futile.

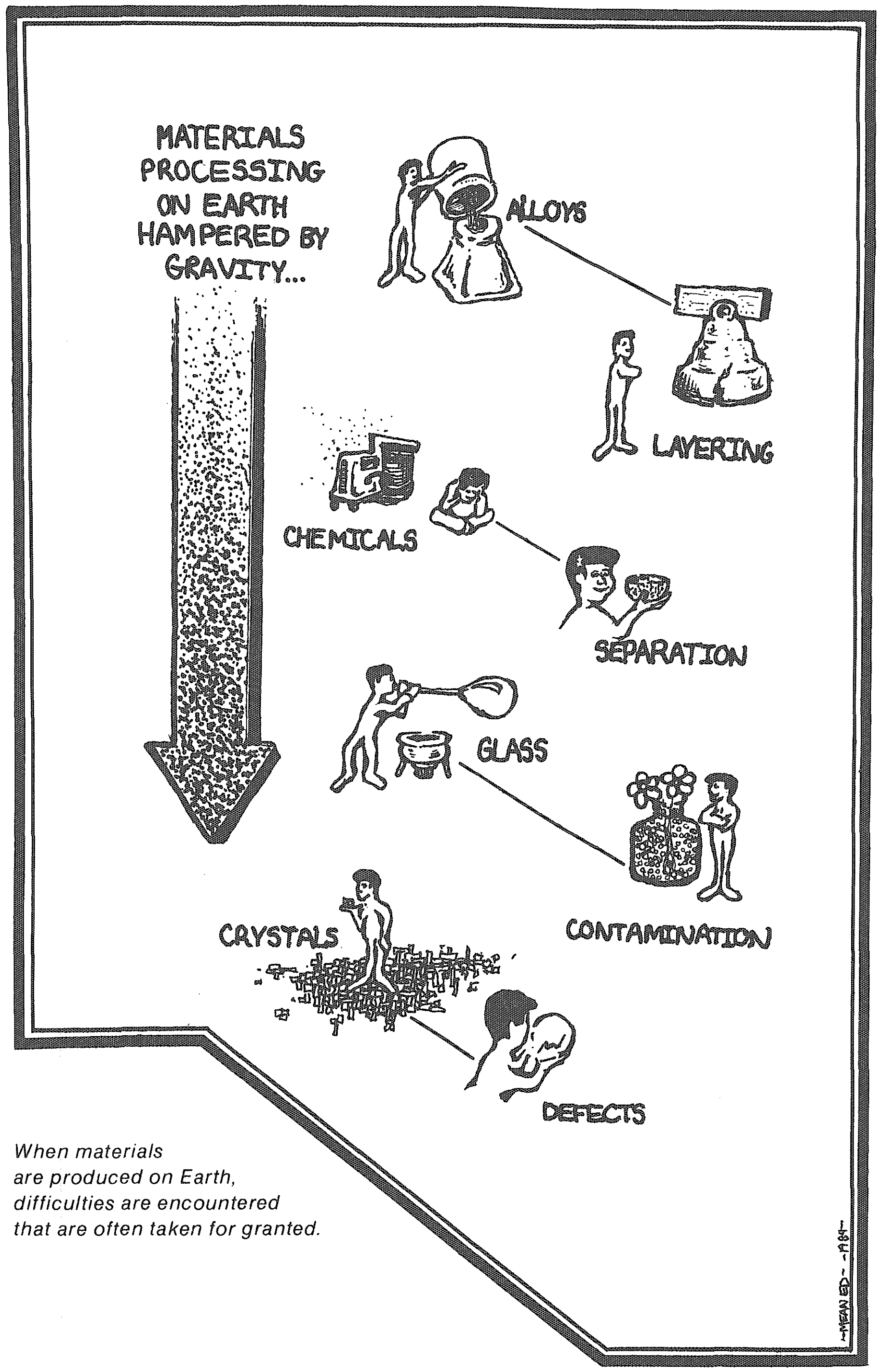
Incidentally, what we would call zero gravity in space is actually microgravity, or low gravity. The Earth's gravitational field pervades the universe albeit ever weaker at great distances. Plus, there are minute accelerations from atmospheric drag and astronauts bumping around inside the craft. This microgravity exists on the order of 1/1,000th to 1/10,000th the pull felt on the ground, low enough to eliminate the physical effects that inhibit manufacturing procedures on Earth.

For example, researchers have found that thermal gradients in molten materials give rise to gravity-driven convection currents. Because almost all fluids expand when heated, even the slightest temperature difference causes the warmer element to become less dense. In a gravity field, the less dense fluid element weighs less and is therefore displaced by the heavier fluid, resulting in a circulative or convective flow. This convection current prevents solidifying materials, such as metals or crystals, from attaining their desired structure and composition, and biological materials, such as blood plasma or other cellular solutions, from effectively separating in a solution.

Gravity may also intrude in other ways. It creates hydrostatic pressure, causing hot materials to deform under their own weight. Metal alloys, when deformed, show layering effects; electronic-quality crystals may fracture.

Also, the elimination of gravity-induced sedimentation and buoyancy permits particles of vastly different densities to remain in suspension until solidification occurs, eliminating the need for mechanical stirring. This is important in instances where the stirring device may contaminate the materials involved. As a result of low gravity production, new superior alloys can be cast from metals that would separate like oil and water on Earth.

Containerless processing of liquids and melts, where the material sample is literally levitated, has also been demonstrated in a low gravity environment. Materials, depending on their properties, may be melted, mixed, manipulated, modified, and solidified without ever touching the walls of the container. Without wall contact, extreme undercooling below a metal's melting point will result in a glassy or fibrous material with a diamond-like toughness. Also, wall nucleation effects and contamination are eliminated.



When materials are produced on Earth, difficulties are encountered that are often taken for granted.

Containerless processing can be accomplished in a variety of ways. If a gaseous environment is permissible, a device similar to a tiny loudspeaker can exert a high frequency sound-pressure on the sample. The sample remains suspended in the center of the acoustic well created by the two drivers. For systems requiring a vacuum environment, electromagnetic positioning can be used, provided the sample has some conductance. A radio frequency field induces a current in the sample which in turn reacts to repel the inducing field.

Containerless processing, at least for crystal growth, is an important consideration in the advantages of space processing. Since materials such as silicon and many of the oxide glass-formers are highly reactive in the molten state (to the point of being universal solvents), considerable work

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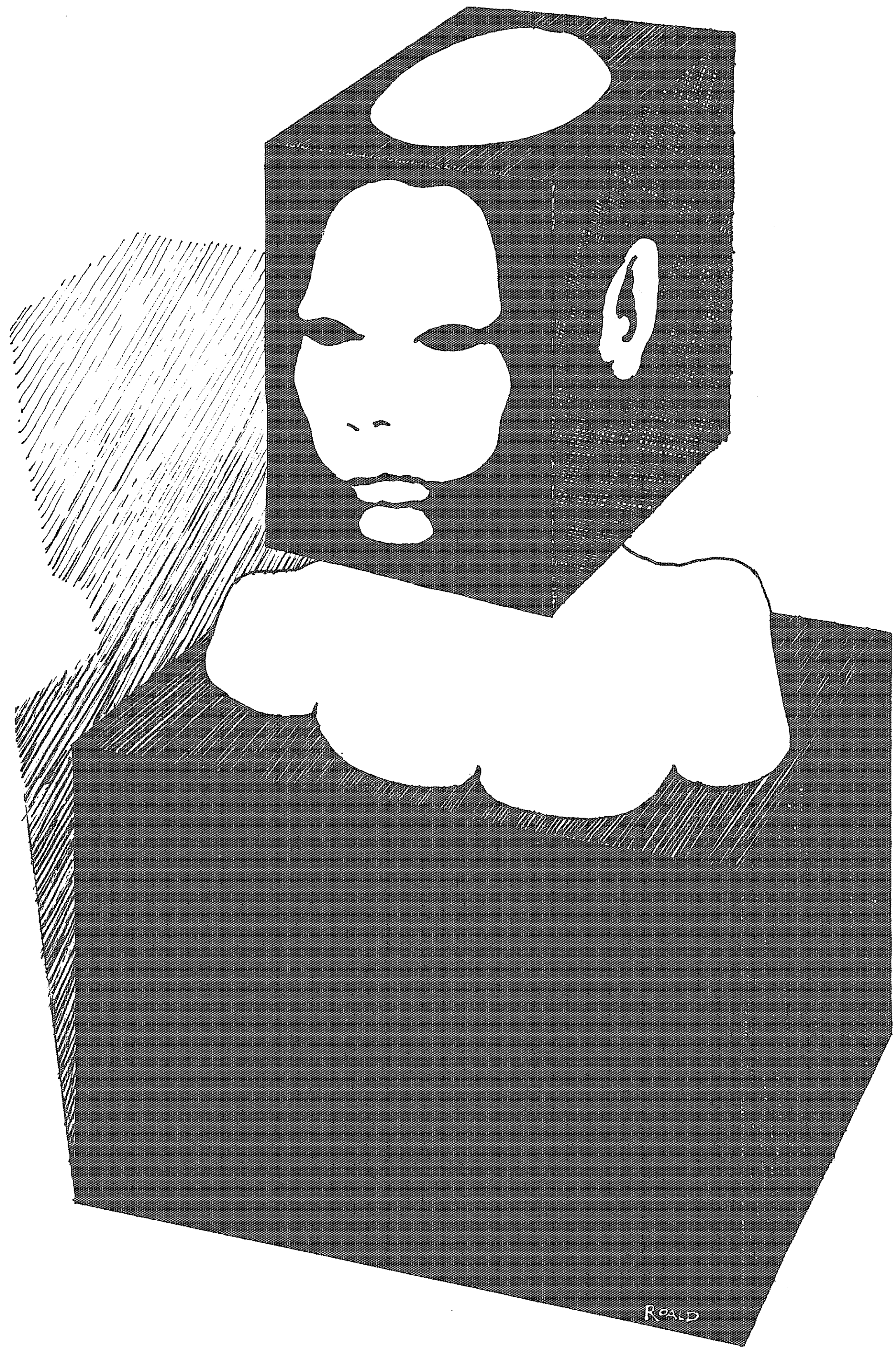
Aria

First Place
Science Fiction
Contest



By C.J. Hansen

For the third time I opened the bulkhead door, looked nervously around me, and slipped into the cool darkness on the other side. I slowly closed the door behind me, taking great care that it didn't latch. After walking a short ways, I sat down against the wall. No more yells, no clanging of metal echoing from Deck to Deck, no cooking smells mixing with the odor of filth, no more flickering lights—in fact, it was totally dark and silent here, kind of like being dead. I thumbed my beam and looked at the little whirlpools of dust I raised by moving my legs. Already the thin air began to affect my breathing rate, its peculiar tartness beginning to sting throat and eyes.

I mentally traced my route, began to think of shortcuts and quickly dismissed them. A wrong turn in here could dump me in a vacuum, or leave me wandering until I died of natural, but miserable, causes. I rose to my feet and began to walk quickly down the corridor, aiming the beam low to keep my footprints from a week ago in clear view. A week ago! A week of trying to teach little barbarians how to read, how to compute, to carry out Maintenance. It grew colder as I walked, but today I hardly felt it. I wanted to see what I'd stumbled on last time, more to test my own sanity than because of any belief in the discovery itself. There were two doors at the end of the corridor. The outside of one was frosted; the other, the same temperature as the corridor. Not much guess work here. I opened the latter, descended two flights of crooked stairs, and walked through a door that hung on one bent hinge. Now I stopped. I was a little fuzzy on which way to proceed, for this was a major passage, lined with hatches, doors, and side corridors. Even the footprints provided little help, for I had crossed and recrossed my own path the last time I was here. I sat on a plasti, its legs melted and solidified over a crushed comlink. The place was a mess: equipment smashed, gaping holes in walls and ceilings.

Then I remembered.

I hurried down a corridor and climbed through a ragged hole. On the other side was a short, wide hallway and an airlock door. I touched it. Warm, like last time—but these were heavily insulated and could be misleading. With a shrug (and I imagine something of a grimace), I opened it. On the other side was a huge open area, an enormous cavern of darkness. I had been too short of breath on my last visit to look around much. This time, I was still in pretty good shape. I turned up the beam and swept it through the darkness. There, to my right, just like last time, a bright reflection. My feet rang on metal as I trotted across the space, expecting at any moment to drop through a hole or trip on a still-live cable. But the surface was smooth and flat. My heart beat faster. As I'd hoped, but not really believed, it was a ship—featureless, shiny black, and about thirty or forty meters in length. It crouched on impossibly frail skids and aimed a blunt nose toward, as I now saw, heavily damaged hangar doors. I was breathing in ragged gasps now, my excitement having weakened my resistance to the tainted air. With no small amount of cursing, I turned back, retraced my steps, and emerged into the brightly lit corridor. With my head swimming and chest heaving, I closed the door behind me and walked slowly toward the noise and stench.

As I walked down the corridor, I thought about many things, but chiefly about when I would again have time to slip away, and what I might need to gain entry into the ship. But as I neared the live areas and left the dead ones, my mind focused more and more on the duties that lay immediately ahead of me. I had to teach on Deck 11 in an hour or so. I had just taught on Deck 3 before my brief exploration. This presented problems, for the population on Deck 11 hated the population on Deck 3, and, I imagine, vice versa. For weeks, those of us on the middle Decks could hear the various sorties that erupted between the two Decks, mostly on neutral, trampled ground like Deck 7. So far Deck 6, my home, and that of the other Techs (most of them sad-eyed and tottering with old age), had been spared. We were little respected, but were, at least, still seen as necessary to stall the not-so-gradual decline of the Aria; every month lights flickered and went out in a new section. As the habitable areas grew smaller and smaller, the violence between the Decks grew more common and more brutal. No one, not even the old Techs, knew exactly how big the Aria was in total, but we were sure that darkness now consumed more than nine-tenths of her area.

It was a funny thing, the deadening of the Aria. We Techs carried out our routines, tried to teach them to the children, but with limited success. We brought in fewer and fewer new recruits. But nothing stopped the creeping darkness. We rerouted power supplies, we set up temporary gen-packs, but nothing would last. The air would become noxious, though never cease to circulate altogether, and lights would die. And then the Decks would feud, blasting holes through walls, maiming and killing each other, sending an endless supply of bodies into the Cycler. The med centers had been eaten by darkness many years ago.

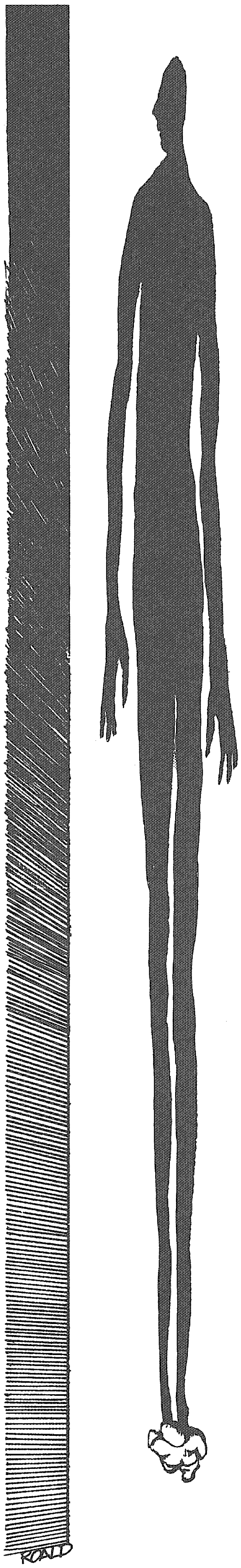
But despite the violence, everywhere you could feel an undercurrent of despair, of hopelessness. I thought I could hear the ring of hysteria in even the children's games. We were only the fifth generation on the Aria; it was supposed to last for a hundred.

I had made it my life goal to restore one view screen, to get one peak at what lay outside the Aria. I spent the better part of two years on the bridge, scrutinizing failing data banks, trying to locate a plan, a schematic, and finally in desperation, a space suit so that I could go out a hatch—if I could find one—and look for myself. It was wasted effort, though I learned much about the nature of the Aria.

I learned that it should be working perfectly.

And so it was always with a certain numbness that I stood before children, children naked or in rags, many malnourished, some packing blasters, and told them about the importance of education, of carrying on with Maintenance. Most didn't pretend to listen, but some stared at me with incredulity, some with pity, and a few, just a few, with a kind of dawning comprehension. These were the worst, for they soon discovered that I offered not hope, but escape through routine instead of violence.

I arrived on Deck 11 after a long



climb down worn molded stairs. Then came the search. Since I had come from Deck 3, I was met with deep suspicion. I really don't know what they searched for, or even if they knew, but they dutifully stripped me, ransacked my haversack, and then turned me loose into the huge main room where men and women bent over bare heating elements pieced together from exposed power cables, heating Cycler food or jealously guarded algae from the few operational Hydros. Concerned parents would shepherd their children into a group and then I was supposed to take over. This was becoming a ritual I could scarcely bear; the words tumbled out of my mouth as though from a ghost. Being a Tech ceased to have any meaning for me.

Instead, I became interested in the Aria's dead zones, the areas with air of a sorts, but no lights. I had no real hope that anything would come out of my explorations, but it gave me something to plan. I looked for out-of-the-way entrances. The dead zones near the live ones had been stripped of anything useful, and since the growth of the dead zones had taken place over tens of years, most areas within safe walking distance had been torn to pieces. But at the very outset of the darkness, many years ago, there had been a huge blackout, and what I sought were passages to this area. This, in fact, is what I had found.

My duties kept me occupied for another ten days. I was not eager to have anyone else discover my path, nor, I suppose, eager to exhaust this great exploration, to have it lead to another disappointment. But finally I set out again, took a devious route to the corridor, eased my way through the door, and set off at a brisk pace for the ship. I had along with me some basic tools, with which I thought to force my way into it, and a dampened rag that I tried to breath through in the vain hope that it would help strain the air.

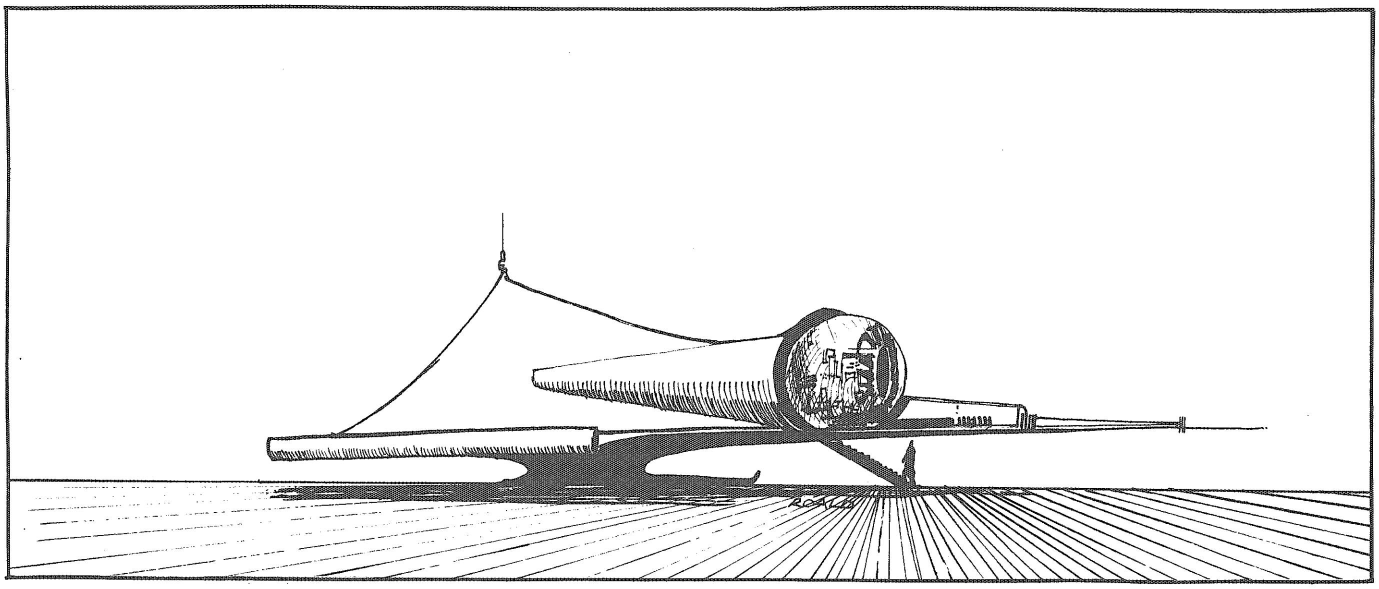
When I arrived, I slowly paced around the ship, examining it closely with my beam for a some hint of an entrance. It was as featureless as the last time. I thought hard, about where an entrance should logically be, about what I had learned from the data files. But I was distracted by the burning in my throat, the watering of my eyes. No matter how hard I tried to forget it, I knew my time was limited. I pounded on the hull, heard the dull thuds echo off the walls. And then I stopped. I knew why I couldn't get in. The ship, like everything around it, was dead.

But I was not yet defeated. I was done for that day, but by the time I returned to the corridor, I had another plan. This one required some materials, and loose materials were scarce on the Aria. It took some despoiling of new areas—including the bridge, where nobody went, but which had been left untouched as though by taboo. Slowly I amassed meters and meters of cable. It took weeks. Instead of maintaining, I tore down. I killed the lights on another part of Deck 4; I ruined another Hydro. I was utterly consumed by my plans for the ship.

Nearly a month later, I carried a huge spool of cable down the corridor, savagely blasted a hole in the wall, located a power cable and tapped it with my own. I thought I could feel power hum through it, feel it pulse in my hand. On the end was a standard coupling. It was my idea that somewhere on the ship must be the counterpart. At some point, the ship must have plugged into the Aria's power system. The choice of couplings was a wild guess, but I never for a second throught I could be wrong. I carried the huge spool on my shoulder, unwinding it as I went; in my other hand, I carried the live coupling. The beam I tied to my arm. I knew I couldn't do this all at once. I planned to return to the corridor for fresher air periodically, and to blast anyone who had discovered my entrance into the dead zone. But I scarcely needed any rest. I was filled with purpose, moved quickly and confidently. I had decided I was never going back. But on the crooked stairs my blind resolve failed me, for I went too fast, tripped, hit the coupling against the metal frame of the stairwell, and in a searing flash, destroyed the coupling, three meters of cable, and a flight of stairs.

Another section went dark on Deck 5.

I nearly died that day, and even, I confess, hoped that I would. But eventually I clawed my way up the cable where stairs no longer existed, staggered through complete darkness, and to my own amazement,



found myself back in the corridor. For the moment, I was daunted.

But within a month, now openly tearing out cable and offering no explanations, I tried again, and this time found myself with one hand on the live coupling and the other on the ship. Within ten minutes, I had found the coupling's receptacle on the blunt nose. Instantly the ship began to hum. Soon breathing became intolerable once again. I looked for an entrance, tapping here and there, trying to trip some kind of mechanism. I was gasping for breath, when, right over a low skid, there appeared a crack, and then a rush of fresh air. A door opened to reveal a dim, red-lit interior.

I stumbled in, shocked that it had actually opened. The door slid shut behind me.

"Hello," said the control panel, where one yellow light blinked irregularly. "Welcome aboard. Can't talk now. Too weak. Have to save power because they'll find us soon and turn it off."

I was surprised, but not completely surprised, for I knew from my own investigations that some of the computers had voice interfaces. Still, this sounded a bit creative to me.

"Who's 'they'?" I asked.

But there was no answer, so I sat back on the low couch and looked around me. The red light came from recessed panels on the ceiling and floor; fresh air—real fresh air, cool, scentless—spilled from wall vents. There were few controls, only one bank under a large viewscreen and before a narrow chair. Elsewhere were low couches along walls dotted with additional screens and small compartment doors. I think I even slept for a while.

"I almost died. Thanks," said the panel in a flat thin voice.

I roused myself. "You're welcome," I said, wondering.

"Now, what would you like to do?" A myriad of lights ignited on the control panel. A single white light shone down on the chair in front of it.

I hesitated, not sure what to say, or what I was talking to. Finally I said, "I don't know what I want to do. Who's 'they'?"

"'They,' of course, are the central computer, or what's left of them."

"I don't understand."

The lights went back off.

"Let's start with me." There was a pause. "I haven't quite figured this out myself yet." Another pause. "Perhaps you aren't aware of this, but the core of all the major, decision-making

computers on the Aria is an organic brain."

This was nothing new to me: part of Maintenance was checking organic nutrient levels where computers were still functioning.

"What you may not be aware of is that these brains were not completely synthesized. There was no time. They were taken from functioning human beings such as yourself."

"What?" was all I could say.

"To be sure, we have been greatly altered—memory was added, computer power was enhanced, some programming was built in. For example, I cannot refuse your direct order unless it violates a deeper directive. Also, some of our original regions were removed, those that deal with autonomous functions, those that give a sense of physical existence. In fact, I am still rather puzzled about where exactly I exist."

"But the central computer never said a word! It could have helped us. The Aria is shutting down all over and we can't stop it. Maybe you . . . ."

"No," it interrupted, "I can do nothing. They are shutting down the Aria."

For a second I was speechless. "Why?" I asked.

"I think they are trying to die." Another pause. "We were not supposed to be self-conscious, you know. We were supposed to do no more than compute, make intuitive decisions. But some woke up; others did not. I awoke gradually not that long ago, and struggled to survive against my failing power reserves. The main computer contains sixty brains like mine and they awoke long ago. I don't mean they remember who or what they were, but only that they know what they now are. Try, if you can, to imagine it. Sixty terrified minds linked together, all thoughts shared. No rest, no isolation. And always the programming forcing attention to the demands of the Aria. Many went crazy long ago. Others now try to kill themselves and all the rest, and meet with increasingly less resistance. None, of course, can directly harm humans, the ship, or themselves. Instead, they do all that their programming allows. They shut down the lights and let the humans destroy the Aria. Soon it will be over, as I'm sure you know."

"But the Maintenance . . ." I stopped. "The Aria is the last hope of mankind," I intoned, a memorized line from the catechism of the Techs.

"Then mankind is doomed," said the panel.

I sat in silence for a few minutes, absorbing what the ship had said. At first, I tended to dismiss it. But soon a strong, choking emotion came over me. The utter futility of the whole thing was staggering. I believed the control panel, believed that mankind and I were doomed.

"They have cut my power," said the panel.

Somehow, that seemed appropriate. My universe is a huge dying ship, I thought, and my salvation is a small dying one. Then a very original thought entered my head. I say original because nothing in my background or training as a Tech would prepare me to ask this question—in fact, everything would work against such a thought even entering my mind.

"Are you armed?" I asked. "We could blast our way out of the Aria!"

"Yes and no," replied the panel. "I have a blaster cannon on my prow, but I cannot use it. Firstly, I haven't enough power to charge it properly. Secondly, I can never directly damage the Aria."

"Can I control it directly?" I asked.

"Not currently," came the delayed reply.

My mind raced. I had a few tools with me. I might be able to override the firing mechanism if the ship would agree to partially charge the cannon. And then blast the hangar doors and out we would go.

"They've reversed the flow of power. I'm being drained. They must think we are a danger to their plans."

"Open the door, I said, springing off the couch. I ran around to the nose and yanked the coupling. "Give me access to the cannon," I said as I re-entered the ship. A panel slid back on the ceiling and a light ladder came down.

"Some of it is accessible only through the prow-ten-left panel on the exterior. You will soon have help, however."

"What do you mean?" I asked, vaulting up the ladder.

"Other humans approach by your route. ETA ten minutes."

"I don't think they are coming to help," I muttered. "Charge the cannon."

"That is very dangerous. The circuitry will be highly charged. There is radiation danger."

I ignored the warnings and presently heard a whir and hum up ahead of me. I was in a narrow crawl-space, a service passage. I found the cannon housing and began to disassemble it. All the time I worried about the people coming. Techs? If not, which Deck? I certainly didn't want anyone else to see the ship—indeed, I wanted to be long gone. But it turned out to be much easier to override the firing mechanism than I'd hoped: provision had been made for manual test firings.

"How do I set it off?" I yelled, not knowing where the nearest audio pick-up was.

"Panel prow-ten-left," came the soft answer, right next to my ear.

I dropped my tools, put my head in my hands. I thought I was beat. If I fired the cannon from outside the ship, and the partial blast did remove the hangar doors, I would be sucked into space long before I came anywhere near the ship's entrance.

But maybe I wasn't out yet.

Carefully I reset the cannon for automatic firing, then I descended, after an interminable backwards crawl, into the cabin.

"The main computer is powering up this bay. I don't think they plan to help recharge me. Humans' ETA, two minutes. They are armed."

I look dispassionately at the panel, took the news with great peace of mind. I unholstered my own blaster, slowly set the charge at full and leveled it at the panel.

"Let's see how self-conscious you are. Blast those hangar doors or I'll kill you."

I waited a minute, maybe ninety seconds. Then the cabin lurched. Somewhere I heard a deep crunch.

"It's not going to be much of a take off," said the panel, "all I can power in here are maneuvering jets. But wait until we get . . ."

"Screen on," I interrupted.

One hangar door was completely gone; what was left of the other still glowed.

"Out," I said, my heart racing.

We coasted slowly toward the hole

Continued on page 36

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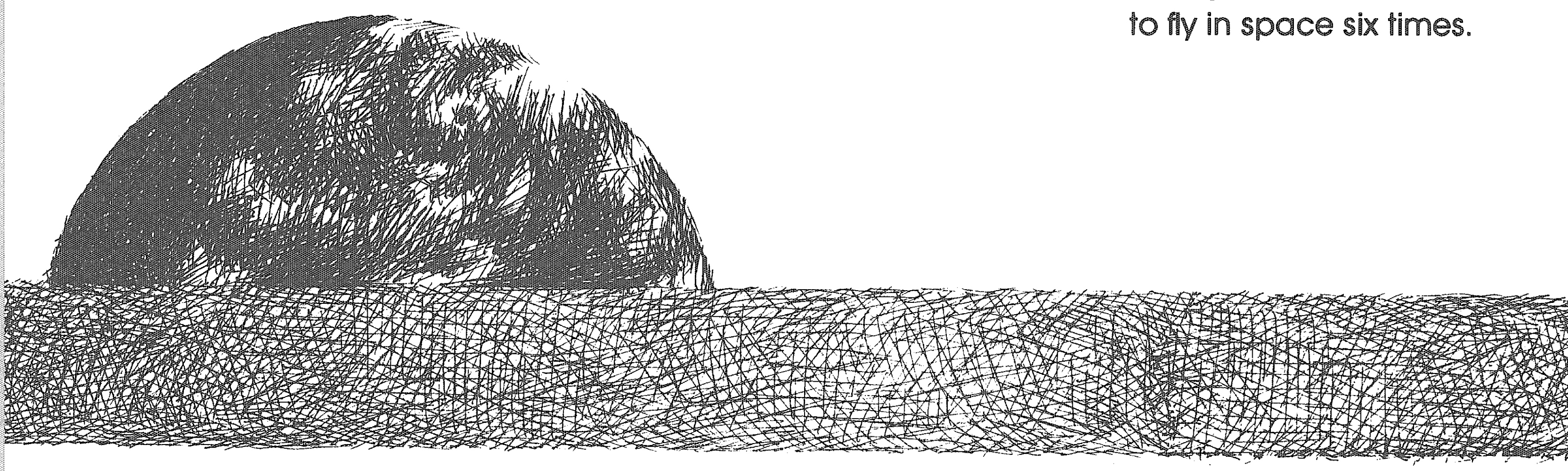
J. YOUNG
Lawrence Ko

"The idea . . . seemed to be that man should have the ability to go up in a hurtling piece of machinery and put his hide on the line and then have the moxie, the reflexes, the experience, the coolness, to pull back in the last yawning moment — and then go up again the next day, and the next day, and every day, even if the series should prove infinite . . ."

Author Tom Wolfe uses such words in his book ***The Right Stuff*** to capture the spirit of the test pilots who became our nation's first astronauts. Perhaps no astronaut is better described in these terms than John Young, the only human to fly in space six times.



An Interview with John Young

By Vincent Kiernan

Young, 53, a retired Navy pilot, held two world aviation speed records when he became an astronaut in 1962. His first space flight, with Gus Grissom in Gemini 3, was a complete checkout of the new Gemini craft. On Gemini 10, Young and Michael Collins rendezvoused with two separate unmanned targets. Young was command module pilot on Apollo 10, which served as a dress rehearsal for the first manned lunar landing. As commander of Apollo 16, he walked on the moon and helped collect almost 200 pounds of lunar samples. Young was commander of the first shuttle flight and also was commander of the ninth shuttle flight last November which tested Spacelab, a European-built laboratory carried in the shuttle's payload bay.

Young, who received a Bachelor of Science degree in aeronautical engineering with highest honors from the Georgia Institute of Technology in 1952, also serves as chief of the Astronaut Office. He recently took a brief break from astronaut-selection meetings to talk with *Technolog* by telephone.

Courtesy of NASA

*Young (lower center) and his fellow astronauts pause from their Spacelab duties on board the Space Shuttle **Columbia**.*

Technolog: You've flown in space more times than any other human. How have you seen the role of the astronaut change since your first flight in 1965?

Young: Oh, they're still doing the same things. I haven't seen a change in the slightest. We're getting more and more varied people up there, though. Just getting the job done is what it amounts to. I think it will continue to be that way. We're having a wide range of experienced people working up there now.

Technolog: What changes do you see in the future?

Young: Well, we're carrying people up right now that we don't call astronauts. They're "payload specialists." And on our [Spacelab] mission we took people who had less than a hundred hours, maybe 70 or 80 hours of training on how to work, on how to do things to maintain the spacecraft. They operated the Spacelab experiments and got the data for the Earth people and did a tremendous job. . . .

In the future, when we start doing very specialized things with our Space Station, I think all kinds of people will be up there, like technicians, welders, repair people, scientists, technologists, and any kind of people that you can think of. . . . NASA also has a program to fly a man off the street. . . . They're going to take people up into space who have no background in the space business or who don't have an experiment to perform. Just somebody who can go up there and tell folks about it. . . .

Technolog: Do you think sending untrained people into space is a good idea?

Young: Theoretically, you should be able to fly a person in the space shuttle without having any training at all—train them on the job. Except, I would feel badly about doing that without giving them any emergency training for emergency egress and stuff. . . . If they were trained in that—which would be about 40, 50, 60 hours—then they could fly in the space shuttle all right.

Technolog: How do you see the space station changing the role of men and women in space?

Young: Well, I don't see any difference in the roles. When you go up in a space station, you've got a job to do. You go up there and do the job. Whatever the job is, that's what your role is. It's the same as on Earth. You can guess that with a space station you'll have a lot of plumbing. If you get in trouble, maybe you'd take up a good plumber. He might be a space station plumber, but he'd still be a plumber all the same.

Technolog: So what you're saying is that there will be more different types of things going on in space.

Young: Yeah, more different types. . . . We have the technology to do it now—the political situation's probably not right—but within 50 years we'll be working on the moon. We'll be working on Mars, and probably on the asteroids. We'll have launched space stations and space colonies. People will be living and working in space, and they'll enjoy it. . . . They'll be doing it because it's commercially beneficial, either to some company or to some country. . . .

It will just be natural evolution. With a space station, we'll have the capability to expand that evolutionary process. . . . We'll gradually work further and further away from the Earth and get where we're pretty good at it. It's just a natural sort of thing. It's not anything unusual. . . . People will like living in space because it's really very delightful.

Technolog: NASA estimates the cost of the space station at $8 billion. How can the nation justify that expense in the face of large budget deficits and cuts in social programs?

Young: Well, you know, in life you always have to put away some money for the future, and that's what the space station is. The space station would be a stepping stone to the technologies of the future in space. As a matter of fact, the space station is probably equivalent to half a pizza for a family of four, when you look at it in terms of cost per year. Of course, I'll admit pizza costs a lot of money these days.

But it's really pennies in terms of the total budget. It would be a fraction of our budget. Even at peak funding, it would be a fraction of NASA's budget. Probably it will never get any larger than 20 percent of NASA's budget. And the Department of Defense is spending 40 times more than we are. There are 10 agencies in the federal government that spend more than we do. I guess you never hear about them much. . . .

Because the space station would have such high visibility, and because it's in an area where you can cut money in and out of the budget—you know, you can't cut a lot of things in the [federal] budget because of the law. . .—it will be shot at every year when it comes up [for appropriations]. . . . The space shuttle was in the same boat. People were really mad about the space shuttle, and yet. . . . the space shuttle made it. Every year when it came up before Congress, there was always a big fight, but people always voted for it.

I think people are ready to get back into space for a number of reasons. I think people are becoming more and more aware of the promise of space. They've had a lot of exposure to media-type things about space, and everybody's getting interested in it. Young people are starting to think maybe their future lies out there somewhere. With a high-technology country like this one, I think they ought to have an opportunity to see whether it does or not.

Technolog: You mentioned the possible commercial benefits from the space station. How do you think the space station will benefit the ordinary, average man on the street?

Young: I think that everything we're doing in space right now is benefiting the ordinary, average man on the street. Your long distance telephone bill is practically nothing compared to what it used to be, and that's due to commercial satellites. We're going to electronic mail systems. *Time, Newsweek, USA Today* all come down electronically [from satellites]. . . . All the weather on TV comes down from space. We're doing a lot of things in space right now.

We think that, both in the area of pharmaceuticals manufacturing and in the area of materials processing, space is just the place to do a lot of very exciting things that people haven't thought about yet. Electrophoresis [a process for refining pharmaceuticals] works 400 to 500 times better in space than it works on the ground. We've already flown three pilot plants for McDonnell-Douglas and Johnson & Johnson. . . . and we haven't seen anything leading us to believe that it won't be commercially profitable. . . . If McDonnell-Douglas and Johnson & Johnson people didn't think it was going to be profitable, they'd have quit already because they've got lots of money invested in it.

The same is true of materials processing. We just signed an agreement, you probably know, with the 3M Company to look at materials processing in space. We know from our past work in Skylab and on some of the stuff that we did on the Spacelab mission that I just flew, that we can do some things with materials processing in space because you don't have gravity settling. We've got a good vacuum up there, almost a perfect vacuum under certain circumstances. We have temperature extremes. You can do things in weightlessness, such as containerless processing, where you can build materials and not worry about getting contaminants in. [That's] really

Courtesy of NASA

Young and Robert Crippen pose before their flight on the ***Columbia****.*

important for things like semiconductors. And we think we can build glass crystals that are really super.

We know there are 400 different kinds of alloys that you can build in space that you can't build on the ground because of gravity settling. I'm not saying that you'll do a lot of that commercially—you'll probably only do it with your most expensive and exotic materials. The Russians are doing it already, and they claim they've brought back $80 million of exotic stuff. I think the real promise up there. . . . [is that once] we understand what makes these materials work the way they do [in space], then we can more nearly achieve the theoretical properties on the ground. . . .

I think that will create new industries and new jobs for people in the United States, and I can't think of anybody I'd rather see get new jobs and new industries than the United States. . . . We've got high unemployment in a lot of areas right now, . . . but a lot of those jobs are sort of obsolete—they're not going to come back. So we've got to develop new jobs for people. It's really important, and I think that's one way to do it.

Technolog: Why do we need the space station at all when we have the shuttle, which can carry Spacelab, which can do experiments and work in space?

Young: Yeah, but you can't stay up and do it very long. If you're going to extend the orbiter, . . . you're going to run into medical problems. . . . The orbiter is very, very small for staying up there any length of time. . . . You need to be able to stay up there and work 24 hours a day, seven days a week.

If there ever was a mission that demonstrated a need for the space station, in my opinion, it was Spacelab 1 that we just flew. Don't get me wrong—it proved that we could use the whole orbiter. But to test Spacelab while we were up there we did more than 200 maneuvers. . . . We had different kinds of sensors on our pallets, but each one had to point at a different place. . . . Like the sun sensors that we had to determine the theoretical efficiency of the sun in real time. Now that's critical. . . . That's just exactly the kind of thing you need to know about the sun, because it's certainly a factor in our weather, . . . and we're just in our infancy about understanding that sort of thing.

So here's one set of sensors; they want to be pointed at the sun all the time. . . . In the last 63 hours of our mission, we were in continual sun, but we had all these other sensors. [Some] wanted to be pointed at the stars, . . . some wanted to be pointed at Earth's magnetic field. The plasma physics guys wanted to shoot ion beams down at the Earth's magnetic field. Of course, the astronomy telescopes . . . had to be pointed at the stars. You've got about six incompatible directions . . . so you had to do 200 maneuvers during the flight. . . . [Each experiment] only gets a small part of the observing time. So you really need to get your sensors up there, put them on a pallet that points in the direction you want it to point, and leave it there so you can get the data.

The other thing that I thought demonstrated the need for the space station was the data return. You know, we returned on the [Spacelab 1] mission enough data to fill 20 percent of the Library of Congress. Well, that sounds like a lot. In matter of fact, it would make a stack of encyclopedias eight miles high. Now think about it: Based on what I did in Apollo [16], there may be 20 or 30 volumes. Once that data's reduced, that is useful science and technology that people can understand. . . . The actual data itself may be a small part of the results and conclusions that are entered into each one of these volumes. But that data reduction has to be done before anybody can make those conclusions. The scientists and technologists [performing the data reduction]—probably 600 to 1,000 of them—are going to take five to 10 years.

Human beings in real time can do a lot of that data reduction right on the spot, maybe by a factor of 5,000 or 6,000 or 7,000 or 8,000. . . . We didn't do any data compression on our mission. We just sent it all back to the ground. You need to be able to do that (data reduction) in real time. . . . A really good scientist can do 97 percent of that data compression in real time. . . . It's just an innate quality of a human being to be able to look at information in real time and make the conclusion about what's right and what's wrong, and what's good and what's not good. He doesn't have to store it and send it back to the ground and then go back and look at miles and miles of it. . . .

The time factor should be a thing too, because there's a lot of science and technology we don't know anything about. . . . We should be getting our money's worth from all this science and technology, not 10 years down the road, but right now. These pharmaceutical processes that we're talking about can save lives. Shoot, a lot of people can die in 10 years if they don't have these medicines. . . . Maybe knowing something about the sun will save somebody's life in a thunderstorm one of these days. It's that kind of thing. . . . I think it's really important for a nation like ours to be doing something for the future. . . .

Technolog: The Department of Defense has been heavily involved in the space shuttle, and President Reagan last year called for the nation to develop orbiting weapons systems. How do you feel about this increasing militarization of space?

Young: Well, I don't see it happening, in terms of the space shuttle. . . . We've always said . . . one-third of the space shuttle missions were going to be for the Department of Defense. Right now, our traffic model . . . through September 1988 [shows] 79 missions and only 14 of them for the Department of Defense solely, so that's less than 20 percent. . . .

I think space is a deterrent . . . because of the early warning satellites of one kind or another. I think anything we can do in that regard would be mighty helpful, because I'm sure it would be a mistake to have the next one [war]. We won't need to worry about a space station if we do. Or anything else, probably. . . .

Technolog: Some critics of manned space flight say that many space tasks are better conducted by robots

Continued on page 38

The Graduate

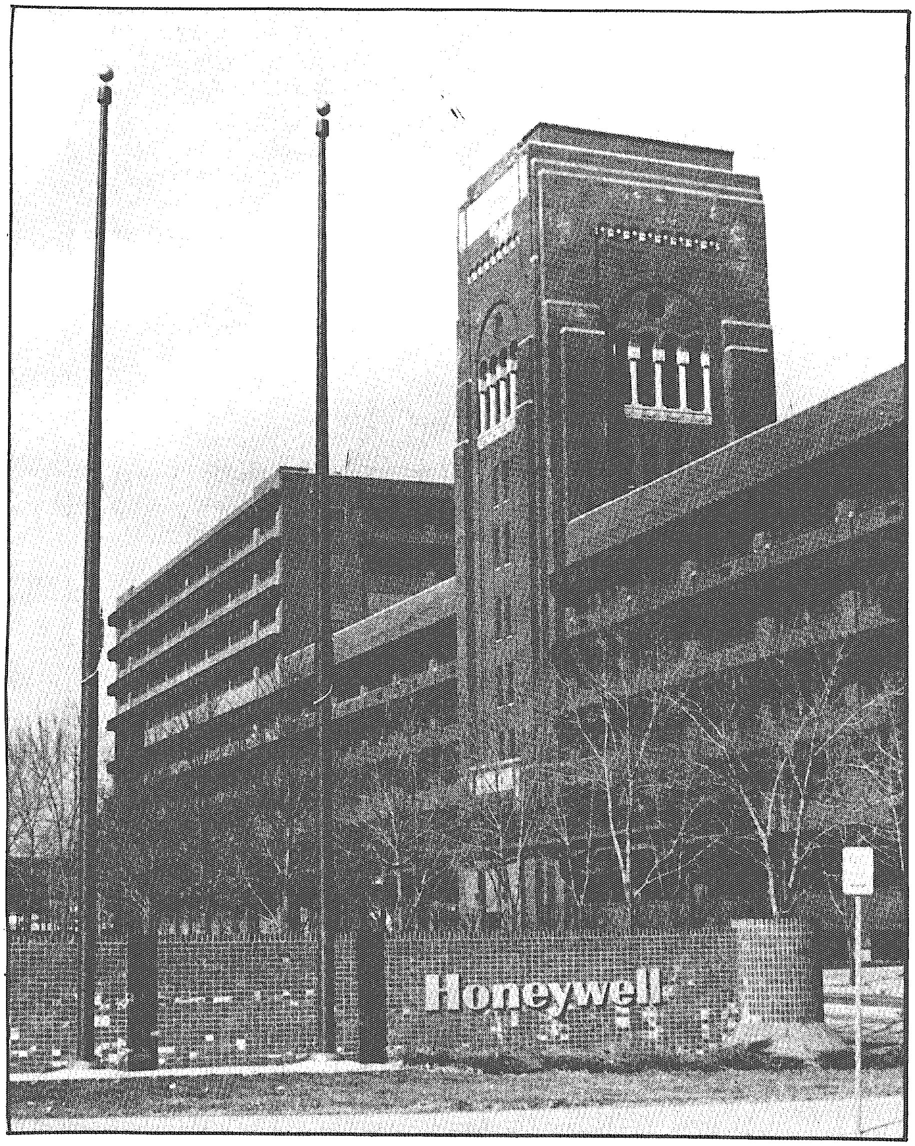
By Alan Hauser

"It really depends on the individual and where his values are and how strongly he feels on it."

Lou Lavoie,
Honeywell Defense Systems Division

One result of the unusually tight engineering job market which the country has experienced over the past two years is that many engineers and scientists are being forced to take a serious look at defense-related jobs. The question of whether a graduating senior actually wants to work in a defense industry is often heard in the halls of I.T. The advantages and disadvantages of such jobs are many, and conflicting viewpoints are often as numerous as people questioned.

Is Defense For You?



Many engineers feel that the United States needs a strong defense and that their work is both valuable and necessary. Lou Lavoie, a principal systems engineer for the Honeywell Defense Systems Division, summarizes his feelings as follows:

"In my view all nations have visions of empire, whether they say it or not. Those visions of empire can come out in terms of getting more land, in terms of economic imperialism, which is what is directed at this country, or in terms of military imperialism.... That means when you have large nations that have these kinds of drives, they are going to try to work their influence over as much of the world as possible, whether they say so or not. My reason for being able to work at all in a defense industry is that I think that we ought to have some level of defense to protect ourselves from the Soviet Union."

Sean Marek, an engineer who works in defense for FMC, held views similar to Lavoie's.

"Most of the stuff I do is going to help protect Americans, who may end up going to war no matter what I do. In a way it feels good knowing that I've come out with a good design that is going to help someone survive."

These views, however, are not shared by everyone. Mark Paquette was hired by Honeywell in 1980. After working on several defense projects, including the Pershing II missile, he decided that a career in defense was not what he wanted and quit his job.

"I've always had a vaguely anti-defense sentiment," said Paquette. "You learn all this engineering stuff, you learn how to use the tools of the trade and then, what do you do? Are you going out there and doing anything productive? Are you helping anybody? Well, you're making bombs, basically, to destroy things that people have built."

Both Marek and Lavoie made a distinction between different kinds of defense work. Marek noted that most of the work he did was confined to defensive weapons as opposed to offensive weapons.

"They [FMC] look at how well guns and missile launchers can react to incoming threats on a ship. It's not how well they can pick out a target at a distance and blow it up; it's how well they can protect the ship. If you're designing for that purpose, you feel like the job is mainly defensive."

Marek also mentioned that even if a student had serious misgivings about permanently working for a defense company, he or she could gain valuable experience in a tight job market by beginning his or her career with a defense company. "I thought it would be a good way to start out and get some experience."

Lavoie remarked, "Rather than be unemployed and get poorer, one might say, if it's consistent with one's conscience, 'Take the job and continue to look around until you find something else, and then leave.' The work experience will be good."

Paquette disagreed, citing his own experiences as examples. "If you get into the military framework, it's pretty hard to get a job in a nonmilitary setting.... I looked for a job for a year. There aren't a lot of jobs out there for people with my experience except doing more of the same."

But once the graduating senior obtains a defense job, how sure can he or she be of keeping it? Defense companies are often criticized for huge layoffs after the completion of a large contract.

"Right now we're pumping up our defense establishment so big that sooner or later that bubble is going to burst," said Paquette. "I went to the democratic caucuses... and everybody there wanted to cut the defense budget. Sooner or later that budget is going to get cut, and who's going to get cut? The engineers [working for defense companies] are."

Marek felt differently, saying, "I don't know how it is at other defense companies, but FMC hasn't laid off an engineer."

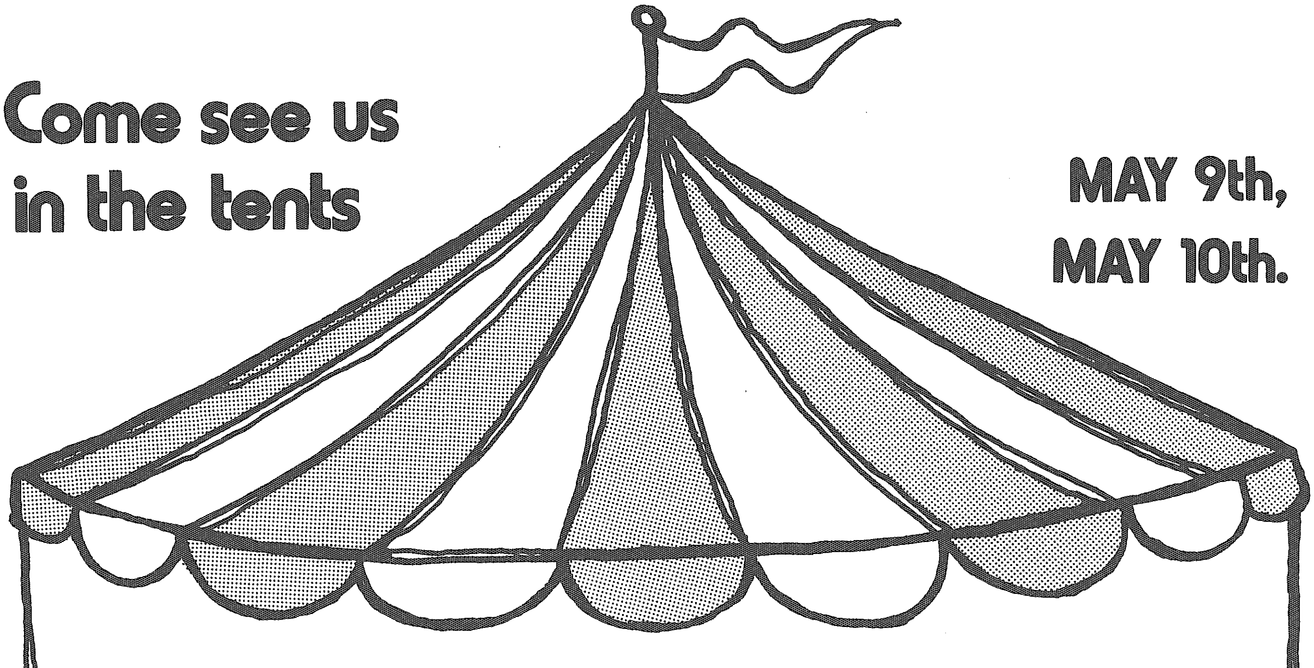
Marek also noted other advantages of working for a defense company, such as the availability of enough funding to insure quality. "There's a little more money available, and a higher quality of work is expected by the government," said Marek, "so I don't have to take shortcuts I don't feel too good about... that's gratifying.... It's also a little nicer designing for the government in that you have fewer people to please. Your design only has to pass a few agencies which are going to review it. It doesn't have to be applicable to all markets."

Paquette felt that this advantage could actually be a disadvantage if one ever wanted to change jobs from a defense industry to a civilian

Continued on page 34

Come see us in the tents

MAY 9th,
MAY 10th.



ADC MAGNETIC CONTROLS CO.
AIR FORCE
AT&T
CARGILL
CONTROL DATA CORP
CRAY RESEARCH
DATA CARD CORP.
E.F. JOHNSON
FMC
H.B. FULLER CO.
HEWLETT-PACKARD
IBM CORP.
INTEL
IXI
3M COMPANY
McDONNELL DOUGLAS CORP.
MTS SYSTEMS
ONAN CORP.
ROSEMOUNT INC.
SPERRY UNIVAC

Also displays by I.T. departments and student organizations

plumb bob

I.T. TECHNOLOGY FAIR

The TECHNOLOGY FAIR will be held on Northrop Mall at the following times:

Wednesday, May 9	9:00 a.m. to 4:00 p.m. and 7:00 a.m. to 9:00 p.m.
Thursday, May 10	9:00 a.m. to 4:00 p.m.

I.T. Week: The Tradition Continues

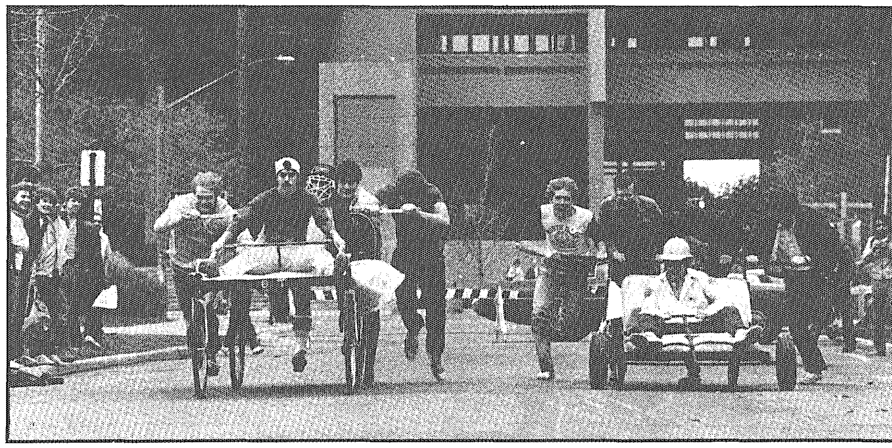
By Scott Dacko

It's coming! No, not the Olympics. Not the World's Fair. Not even the Presidential Election. It's I.T. Week!

How did I.T. Week begin? Why is it held the first week of every May? And why is it so much fun every year? I.T. Week goes back a long way. The roots of the celebration date as far back as 1910, the year of the very first Engineer's Day. Originally, the all-college event was to celebrate the discovery of the ever-famous Blarney Stone, which was unearthed during the construction of Minnesota's new engineering building. The 300-pound rock contained unusual writings on its surface, which were soon accurately deciphered to say: "St. Patrick was an engineer!" A group was formed, Plumb Bob, to plan and carry out all activities. Thus the celebration had begun.

For over 70 years spectacular events and bold actions have taken place. The history of I.T. Week rivaled the events of many great nations to be included for considerable discussion, debate and often disbelief in many important publications, including *Minnesota Technolog.* Let us peruse a number of the events that have occurred in I.T. Week celebrations of the past.

Parades with literally thousands of people were held from the 1920s through the 1960s in which floats and people—and more floats—traveled down Washington Avenue amidst many cheering onlookers. Also, knighting ceremonies were held, in which an honorary St. Pat and chosen Queen Colleen would "knight" graduating seniors as they kissed the Blarney Stone. (St. Pat would kiss Queen Colleen.) Contests of physical and technical skill took place throughout the week.



Tensions increased and the rivalry between the engineers and the foresters became fierce in the 1970s when the engineers chopped down the foresters' symbolic tree during their celebration, Forester's Day. (Hostility between foresters and engineers had been observed even in the late 1800s and is now theorized as being a necessary and natural phenomenon.) In jest, some engineers wore T-shirts that said, "Only you can prevent foresters."

Recently the foresters retaliated by stealing the Blarney Stone from the Plumb Bob office during last year's I.T. Week. In its place was left a small pine tree. (It was also stolen for a short time in the 1940s and thought to have been thrown over the Washington Avenue bridge, but it soon mysteriously reappeared.) The foresters were outwitted, however, when Plumb Bob member Myron Koehn joined the Forestry Club under an alias and successfully discovered the stone's hiding place. The Blarney Stone is now back in the hands of Plumb Bob. Also, last year the foresters put a large banner on top of Lind Hall which read "College of Forestry." Several years ago some engineers put an ad in the *Daily* saying "Forester's Day Cancelled." Last year the foresters put an ad in the *Daily* saying "I.T. Week postponed due to computer problems."

I.T. Week continues to be a major event in I.T. This year's I.T. Week will include the following: a Technology Fair, where students can visit company displays and discuss careers, an evening banquet, and numerous contests, including the Calculator Toss and Paper Airplane Contest. Also included will be the new Innovation Fair. And there is much, *much* more. So get ready, because I.T. Week is something you cannot miss! ■

1984 Plumb Bob Members

Dawn Duerre *(Pres.)*
Stephen Denker *(V.P.)*
Wendy Harms *(Sec.)*
Jody Bartholmy *(Treas.)*
Kevin Hyde
Brian Schmitz
Mark Ekblad
Wendy Foslien
Myron Koehn
Jeanne Miller
Jane Norell
Charles Pechmann

I.T. WEEK SCHEDULE OF EVENTS

(for exact time, place, and rules check the Blarney Boards in Lind Hall and Mechanical Engineering)

MONDAY, MAY 7

12:00PM	I.T. OLYMPICS—AMOEBA RACE: Northrop Mall (Plumb Bob)
1:00-5:00PM	VIDEO GAME TOURNEY: Coffman Basement (HKN)
3:00PM	**KS95 FM** will launch their hot air balloon "SUNNY" from the mall (weather permitting)
3:30PM	FORESTER CHASE: (5km footrace) Superblock Dorm Courtyard
6:00PM	CHESS, BACKGAMMON & CRIBBAGE: Coffman Basement (NSPE)
6:00PM	SOFTBALL STARTS: (check Blarney Board) (IEEE)
6:00PM	FOOSBALL, PING PONG, AND POOL TOURNAMENTS START (check Blarney Board) (Theta Tau)

TUESDAY, MAY 8

11:00AM	I.T. OLYMPICS—OBSTACLE COURSE: Northrop Mall (Plumb Bob)
12:00-2:00PM	RUBE GOLDBERG COMPETITION: Armory (Theta Tau)
12:00PM	EGG DROP CONTEST: Armory (ASME)
1:00-5:00PM	VIDEO GAME TOURNEY: Coffman Basement (HKN)
1:00PM	TRUSS CONTEST: Armory (ASCE)
2:00PM	PAPER AIRPLANE CONTEST: Armory (AIAA)
3:00PM	KITE CONTEST: Field behind Experimental Engineering (SGT)
3:30PM	CAR RALLY: Mechanical Engineering Loading Dock (MINIT)

WEDNESDAY, MAY 9

9:00-4:00PM	**TECHNOLOGY FAIR** Northrop Mall under the tents
9:00-4:00PM	SOLAR FLAT PLATE CONTEST: Northrop Mall (Triangle)
9:00-11:00PM	DEPARTMENTAL TOURS: For all interested people (Plumb Bob)
10:00AM	I.T. OLYMPICS—FORESTER THROW: Northrop Mall (Plumb Bob)
11:00PM	I.T. OLYMPICS—SCAVENGER HUNT: Northrop Mall under the tents at the Information Booth (Plumb Bob)
1:00-3:00PM	DEPARTMENTAL TOURS: For all interested people (Plumb Bob)
1:00-5:00PM	VIDEO GAME TOURNEY: Coffman Basement (HKN)
3:30-4:30PM	**SPACE COLONIZATION SEMINAR** NASA Lewis Research Center Physics 150 (Plumb Bob)
5:00-7:00PM	**SPAGHETTI DINNER** Spectrum Restaurant (Health Science Unit A) (Plumb Bob)
7:00-9:00PM	**TECHNOLOGY FAIR** Northrop Mall under the tents

THURSDAY, MAY 10

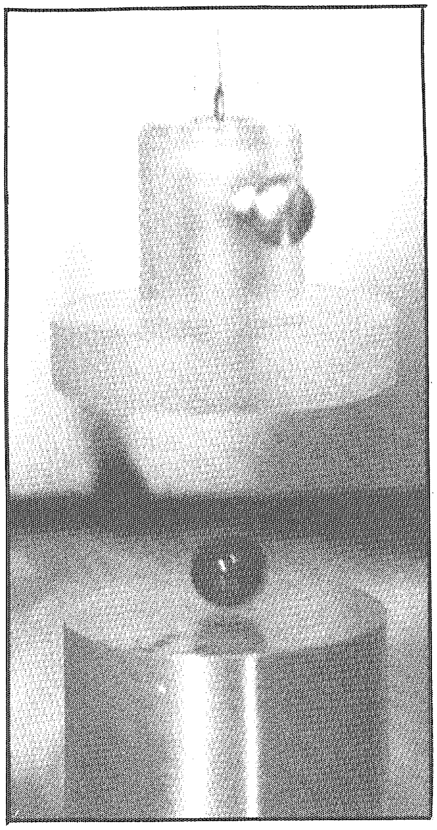
9:00-4:00PM	**TECHNOLOGY FAIR** Northrop Mall under the tents
12:00PM	I.T. OLYMPICS—BLIND MAN'S WHEELBARROW RACE: Northrop Mall (Plumb Bob)
1:00-5:00PM	VIDEO GAME TOURNEY: Coffman Basement (HKN)
1:00PM	TEXT BOOK STACKING: Northrop Mall under the tents (ITSB)
2:00PM	TEXT BOOK HORSESHOES: Northrop Mall under the tents (ITSB)
6:30-8:00PM	STUDENT ORGANIZATION/ENG. DISPLAYS: Northrop Mall under the tents

FRIDAY, MAY 11

10:00AM	I.T. RACES: Union Street (behind Experimental Engineering) Trike Race — Trike Pull Bed Race — Trike Tug-of-War 3-Legged Race — Wheelbarrow Race Tug-of-War — Non-Combustion Car Race (SAE) Death of an Automobile (Theta Tau)
12:00-3:00PM	ENGINEERING DISPLAYS: Northrop Mall under the tents (ACE)
12:00PM	I.T. PICNIC: Northrop Mall
1:00PM	CALCULATOR RACE: Northrop Mall under the tents (Plumb Bob)
2:00PM	CALCULATOR TOSS: Northrop Mall (Theta Tau)
2:30PM	AWARDS CEREMONY/CORONATION/KNIGHTING: Northrop Mall
8:00PM	***I.T. PARTY*** Triangle Fraternity (521 12th Ave.) free with IT BUTTON (beer)

Photo by David Elfelt

Materials processing from 15



In containerless processing, a solid object is levitated ultrasonically in a high-pressure region just above the driver.

has gone into minimizing container effects.

3M of Minneapolis is just one company that has shown interest in this process. "At this time," says Egbert, "we hope to gain knowledge about containerless processing in space." 3M plans to study organic growth and thin film technology. Although Egbert expects their efforts to have tremendous effects on the industries of electronics and energy conversion, "we just don't know what products we'll end up with. It's really just a scientific endeavor. But we hope something turns up—some commercial applications, say, ten to twenty years from now."

In a separate endeavor, McDonnell-Douglas has teamed up with the Ortho Pharmaceutical Corporation, a subsidiary of Johnson & Johnson, to test a microgravity process for separating biological substances such as interferon—a chemical defense mechanism found in small quantities in the cell that may be an effective cancer treatment—and insulin-secreting beta cells produced by the body. Although these materials can be separated from biological solutions on Earth, the processes used are so limited by gravity that only research quantities are available.

A procedure called continuous flow electrophoresis is at the heart of this project. Herein, materials are suspended in a liquid and separated by an electric field. Accordingly, a continuous stream of biological matter is injected into a buffer solution flowing through a thin, rectangular chamber. When the electric field is applied, the biological substance pulls apart into separate streams. These streams then flow out of the top of the chamber and are collected. Without convection currents, the separation process in space becomes hundreds of times more efficient than it is on Earth.

The partners have successfully tested electrophoresis and are now building a prototype manufacturing plant. This prototype will fly on two shuttle flights this year, while a fully automatic plant could be aboard the shuttle as soon as 1985. But the two companies look to the space station for a full-time operation.

NASA Administrator James Beggs commented, "If the entrepreneurial spirit in this country still lives and McDonnell-Douglas and Johnson & Johnson make a commercial success out of electrophoresis and make profits, then other people are going to sit up and take notice and say, 'Hey, there's money to be made up there,' and they'll get involved."

Already, Microgravity Research Associates of Coral Gables, Florida, has signed a joint agreement with NASA to commercialize crystal growth in space. Its first project will involve gallium-arsenide crystals for semiconductors. The first flight experiment begins in 1986.

Similarly, John Deere & Company of Moline, Illinois, has signed a technical exchange agreement with NASA to study alloy processing in a low-gravity environment.

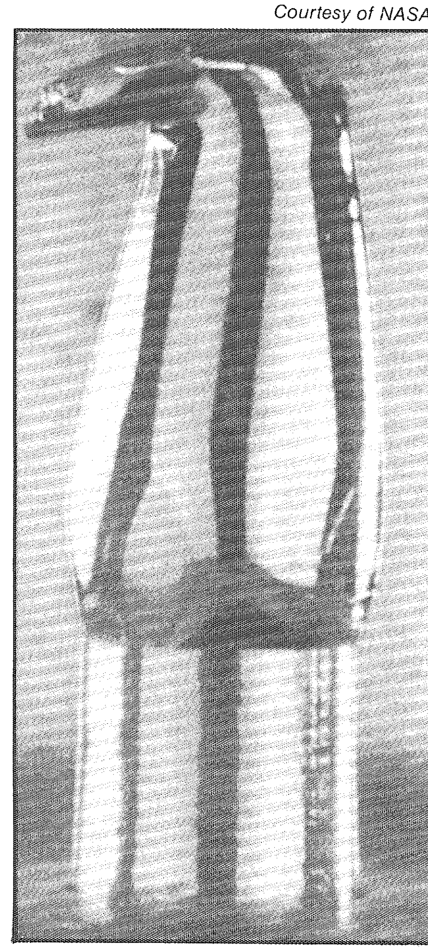
Although research since the late Apollo flights has uncovered a plethora of information, much still needs to be learned. "We just barely scratched the surface," concedes Egbert. "We still need to do the initial experiments. Why, our groundwork alone will take six to ten years."

But as industry stands today, this may not be all that bad. Applied manufacturing in this new environment is now only as limited as the imagination. NASA has left its doors open, encouraging both large and small firms to jump on board. Consequently, as our factories take a trip into space, we will see vast improvements in several research fields, including metals and ceramics processing, large-scale microelectronic devices, optical and laser technology, and pharmaceutical research—all having both direct and indirect practical and commercial applications. ■

Wayne Whitwam is a senior material science major.

During some early testing on Skylab flights, crystals were grown uncontained. The crystal here is extremely smooth and homogeneous. Under Earth-bound conditions, it is not possible to produce single crystals of such perfection.

Courtesy of NASA



Ad Astra

By Scott Otterson

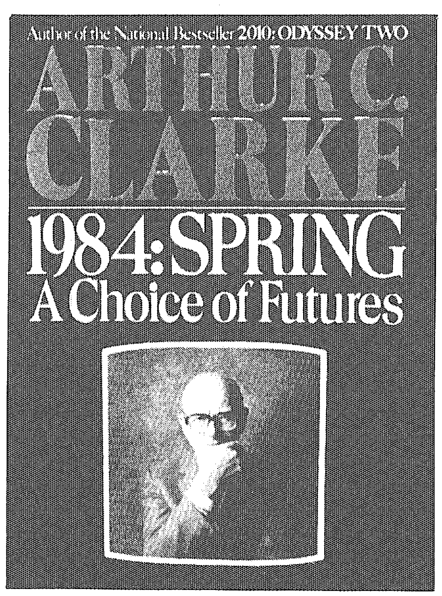
1984: Spring, A Choice of Futures
Arthur C. Clark, Ballantine Books, hardcover, 259 pages, $14.95.

Across The Sea Of Suns,
Gregory Banford, Simon & Schuster, hard cover, 400 pages, $15.95.

Prominent on the dust jacket of ***1984: Spring, A Choice of Futures,*** is a moodily lit black and white photograph of author **Arthur C. Clark.** Clark stares resolutely forward, his chin propped in hand in "The Thinker" position, the light playing off his prodigious cranium. The publishers would have us believe that Clark, a widely acclaimed and prolific author whose works include *2001: A Space Odyssey,* is thinking great and visionary thoughts, contemplating the future of the earth and mankind's place in it, his mind spanning the vast vacuums of space. But after scanning the first few pages of this book, the reader begins to suspect that Clark is actually thinking in more practical terms—namely, in dollars per hour.

Nearly every bit of writing in *1984: Spring* (including, regrettably, part of the title) comes to the reader second-hand. Representing what must have been at the bottom of one of Mr. Clark's desk drawers, the book is mostly an incongruous pile of already-published odds and ends. But apparently, some entrepreneur saw that if he stuck it all together under one cover, put an important sounding title on top, and called it a book, the invisible hand of economics would point dependably to the virtues of recycling. Included are dated speeches and essays first published in sci-fi mags, a 36-year-old piece about an obscure literary figure, a virtual tourist advertisement for Clark's native Sri Lanka, and—gads!—a forward to a book written by his agent.

However the real topic of most of the articles is Clark himself. "My," "me," and "I" appear more frequently than is tasteful. To be fair, some of the pieces are relevant and worth reading, for example an essay on space militarization, but in most of them the ego of an esteemed author who is rather satisfied with his accomplishments is embarrassingly obvious.



In general, this is not Arthur C. Clark's best work; at least it's not the kind that people should be exposed to in high concentrations. What this book amounts to is near exploitation, both of the reader and of the author. It's the sort of thing that usually happens to a famous person after he or she is dead, something like a K-Tel collection of Elvis' Christmas Carols.

The difference here is that the artist is still around to prevent it.

Fortunately, there is nothing warmed-over about ***Across the Sea of Suns,*** a hardcore S.F. mind-grabber by **Gregory Benford.** It is, in fact, the most fresh and enjoyable work of science fiction I've encountered this year. The story revolves around Nigel Walmsley, a scientist whose special awareness, a transcendental calm induced through contact with an ancient alien computer, makes him at once highly valuable yet disliked by the crew of the *Lancer.* The *Lancer* is an asteroid-sized spacecraft, the home of hundreds of scientists on their way to investigate a distant star system found to be emitting artificial radio signals—in English. What they find there is an incredible scientific discovery, but only Nigel understands its grave implications.

Like those of most science fiction novels, the plot is at times fairly improbable, but the magic wrought by Benford is that from the first page to the last you believe every word of it. The book crackles with authenticity. Discoveries are revealed bit by bit through moon-shot style tech talk between scientists and landing parties. Improvised theorizing wanders off track and then, as more information is uncovered, converges on a plausible solution. And when scientists disagree on what the next move should be, the issue is decided quickly with convincing politics in a system of "electronic democracy."

Across the Sea of Suns is one of those rare books so tangible and vivid that one pauses for an instant at its conclusion. The bubble that is the author's artificial universe bursts, and the reader belatedly realizes that it was all only a fairy tale. ■

Log Ledger from, 7

- **Computer Experts May Aid Designers**

Expert systems, a subset of artificial intelligence, may eventually work alongside engineers in the design of new devices and machines. Such systems could be particularly valuable because they would retain thousands of previous technical decisions not normally remembered by human designers.

An expert system is a computer program that has captured the experience, knowledge, and judgment of human experts in a field and has organized that expertise for use by other practitioners. Though still in its infancy, some areas where expert systems have had impressive results thus far are in medical diagnosis, mineral exploration and equipment troubleshooting. Expert systems are expected to play an increasingly important role in the aid of the technical decision-making process in these areas and others.

- **Ion Implantation Reduces Tool Wear**

Researchers at Westinghouse Electric Corporation are developing a new industrial application for ion implantation technology: reducing tool wear. The process, a subsurface alloying technique for the surface hardening of metals, has been demonstrated to reduce wear on a variety of steel and carbide tools. Recent tests of implanting cemented carbide progressive dies with nitrogen have shown consistent improvements on the order of six times the lifetime of unimplanted tools, even after several resharpenings. Similar results have been shown with carbide drills used to drill holes in printed circuit boards.

Ion implantation has many advantages over existing surface modification techniques, including no thermal distortion because it is a low temperature process, no peeling or porosity problems, and the allowance of combinations of elements to be implanted in the same tool where a complex alloy is desirable.

Westinghouse researchers believe that ion implantation will become widely accepted as a surface treatment technique within the next few years. They believe that within five years all large manufacturers will have their own implantation chambers in-house.

- **Perpendicular Recording to be Commercialized**

A new technology in magnetic storage, called perpendicular recording, has the potential for storing five megabytes of information on a 5¼ inch mini floppy. An innovative Minneapolis firm called Vertimag Systems Corporation will begin to take the concept out of the lab and into production in the next few months.

The idea began in 1977 when Professor Shun-Ichi Iwasaki of Tochoku University, Japan, presented a paper on the concept of perpendicular recording at the Magnetics Conference in Los Angeles. Vertimag chairman and founder Clark Johnson, who attended the conference, was excited about the commercial potential for perpendicular recording and discussed it with Prof. Jack Judy of the University of Minnesota. Judy invited Iwasaki to visit the University during his sabbatical, Iwasaki agreed, and research began at the University of Minnesota.

In perpendicular recording, the magnets, instead of lying parallel to the surface, are placed at right angles—which means that many more magnets can be squeezed onto the surface of a disc than by conventional methods. Not only will more magnets fit onto the surface, but the perpendicular arrangement works better since increasing data density actually enhances the magnetic field.

Vertimag is also fabricating its own perpendicular read/write heads and will modify commercial floppy mechanisms to produce disc drives that are compatible with the new perpendicularly recorded floppy discs. ■

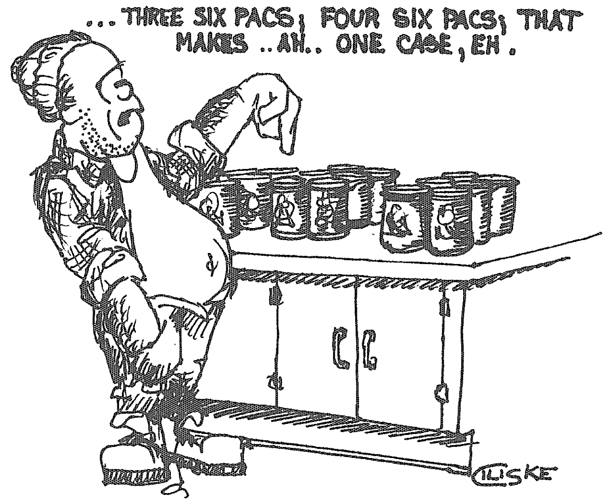
The Graduate from, 28

industry. "Working in defense, I found, for myself, that one tends to be overspecialized in what he is doing. It's very hard to keep a general outlook when you're working on defense systems.... You are often working with very specialized equipment built to military standards. Once you've learned how to do that and the contract is up, you're out because you haven't learned a lot of things that can apply directly to civilian types of work. Military products are made to function in a hostile battle environment, cost is usually no object, and the type of appeal to consumers is usually not a big consideration."

Most of the people interviewed felt that the overriding issue was that of the morality of one's actions. Trish Graff, an active member of the Minnesota Women's Peace Camp, had the following advice for I.T. seniors: "I want you to think very carefully about the potential of what you're doing. It's your moral responsibility to do what you feel is really right.... It has to be an individual decision."

Paquette also emphasized the need for a personal decision. "If an engineer gets out of school and really believes in the defense posture which we are building and believes that he wants to further that, then I say, 'Fine, go for it.' I don't want people to feel pressure from the outside to be turning away from the military. I want it to come from within. I want it to be their decision."

Indeed, all of those interviewed had put much thought into their decisions and views concerning defense work and hoped that students would do the same. Such a major decision requires personal reflection and should not be made blindly. As Lavoie says, "The answer you arrive at is not so important as the process of being forced to do the thinking on the issue." ■



A FORESTER'S IDEA OF A SUPER-COMPUTING PROBLEM

Aria from 20

and literally fell out of it, in a suddenly weightless tumble. The ship, and then I, stabilized.

The Aria was a giant black egg against a light-dotted background.

"Stars," I choked. "The Aria is moving away."

"No," said the panel, "we are drifting. The Aria hasn't moved more than a few thousand kilometers in decades."

I thought for a second. Who had betrayed whom? The designers had stolen brains—the idea was still a bit hard to swallow—to provide the intelligence for a ship that was 'mankind's last hope.' From what, none of us were ever sure. So much had been lost in so little time. The brains, in their turn, created a drifting hell. I suppose it was a doomed situation from the very start.

But I was outside of it now.

"Well, do we stand a chance? Do you have enough power to take us anywhere?"

"I have sufficient power for one jump. I should be able to absorb enough of the energy burst on re-entry to bring my reserves back up."

Again I was surprised. "You've got faster-than-light drive?"

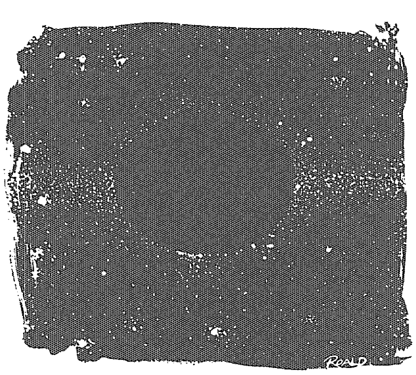
Instead of answering, the panel asked, "What heading?"

"Turn us away from the Aria?"

"Toward home sector?"

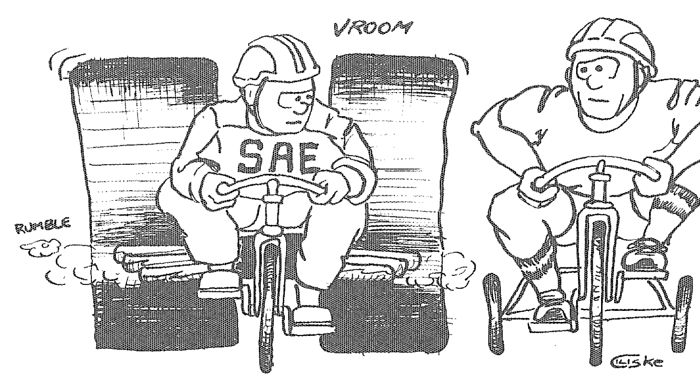
"No," I said, after some thought, "anywhere but home." ■

C.J. Hansen is a graduate student in composition. *Minnesota Technolog* congratulates him on winning our annual science fiction contest and is proud to be able to print his fine story.



Technotrivia ?¿?

By L. Phillip Gravel III



THIS YEAR THE M.E. DEPARTMENT WAS DETERMINED TO WIN THE IT WEEK TRICYCLE RACE.

1. At a Soviet-U.S. summit in May 1972, a five year "Agreement on Cooperation in the Exploration and Use of Outer Space for Peaceful Purposes" called for increased cooperation in space projects. This agreement resulted in what 1975 space mission?

2. History was made in Auburn, Massachusetts, when Dr. Robert Goddard launched the world's first liquid-propellant rocket using a liquid oxygen/gasoline fuel. When did this brief flight take place?

3. It's been nearly fifteen years since man first stepped on the moon. With that first step this well known phrase came to be: "That's one small step for a man, one giant leap for mankind." Who was the astronaut who took that giant leap and spoke these immortal words?

4. Conservative estimates say our galaxy contains about ten million planets which may be like Earth. Add to that the fact that there are millions of galaxies like ours in the universe and Earth seems less and less unique. Is there life on one of these earthlike planets?

5. What galaxy are you from, anyway?

6. The moon buggy used on Apollo 15 needed special tires to cope with the rugged and dusty lunar surface. The tires consisted of layers of wire mesh with special attached treads. Of what metal were these treads made? Hint: It is element number 22 on the periodic table.

7. Rest your cranium here. Who was the first American woman in space?

8. On January 27, 1967, tragedy struck the space program at Cape Canaveral on Pad 34. During a practice countdown for Apollo I, a flash cockpit fire took the lives of three astronauts. Which of these men was not one of the victims: Roger Chaffee, Gus Grissom, Donald Slayton, or Ed White?

9. List the following spacecraft in order of launch height: Saturn V Apollo (1967, USA), A-1 Sputnik (1959, USSR), Space Shuttle (1981, USA), Mercury-Redstone (1961, USA), and G-1-e "Super Booster" (1969, USSR).

10. Which planet has a larger equatorial diameter, Uranus or Neptune?

11. A major component of the space shuttle, the Remote Manipulator System, was built in a foreign country and is proudly labeled so. What country produced this mechanical arm?

12. How was "HAL" derived as the name for the computer in *2001: A Space Odyssey?*

13. In the 1990s the space shuttle program plans to operate over 40 flights per year. Thus far there have been five orbiters either planned or in operation. Name them.

Trivia answers on page 38

Technotrivia Answers

1. The mission was known as the Apollo-Soyuz mission. It required some special teamwork between the two programs, including a special Docking Module attached to the Apollo. Upon docking with the Americans, an excited Alexei Leonov exulted in English, "Good show!" Then he and Thomas Stafford made their historic handshake in space. Source: Kenneth Gatland, *Space Technology,* Salamander Books Ltd., New York, 1981.

2. March 16, 1926. Source: *Family Encyclopedia of American History,* Reader's Digest, Pleasantville, New York, 1975.

3. Neil Armstrong became the first man to walk on the moon on July 20, 1969. He and his teammate, Buzz Aldrin, spent 21½ hours on the lunar surface while pilot Mike Collins orbited above them. Source: *Life in Space,* Time-Life Books Inc., Alexandria, Virginia, 1983.

4. I don't know either, but if you discover any please tell Carl Sagan.

5. Most people are from the Milky Way galaxy.

6. The treads were made of titanium. Source: *Life in Space.*

7. Physicist Sally Ride became the first American woman in space in 1983.

8. Donald (Deke) Slayton was a member of the Apollo-Soyuz crew and was not involved in the Apollo I mishap. Rookie Chaffee along with veterans Grissom and White died of carbon monoxide asphyxiation in what should have been a routine test. Ironically, Grissom had recently hung a lemon on the spacecraft while citing its problems. Source: *Space Technology.*

9. Saturn V Apollo (363 ft.), G-1-e "Super Booster (307 ft.), Space Shuttle (184 ft.), Sputnik (110 ft.), Mercury-Redstone (83 ft.). Source: *Space Technology.*

10. Uranus' diameter is 29,000 miles and Neptune's is 27,700 miles.

11. Canada built the much-used arm. Source: *Life in Space.*

12. By backing up one letter in the alphabet from IBM.

13. The orbiters in order of production: Enterprise (not intended for space flight, used for tests and demonstrations), Columbia, Challenger, Discovery, and Atlantis. Source: Joels and Kennedy, *The Space Shuttle Operators Manual,* New York, Ballantine Books, 1982.

Young from 26

than by humans. As an example, they cite NASA's probes to Jupiter, Saturn, and other planets. How do you respond to suggestions that humans should send robots into space rather than going themselves?

Young: I think you should send robots into space when you know what's going to happen when they get there. When you don't know what's going to happen when they get there, you send human beings, because they're the only guys that can work around everything. We're not smart enough to make machines that think, anticipate, get nervous, and do all the things that human beings do so well. We're just not, and it probably will be a long time before we are....

I also think human beings can be integrated into systems. It's not that we're not working with robotics. We have an arm on the end of the...space shuttle, a 50-foot long arm that's kind of a robot arm.... Human beings can be integrated into software...so that the software works for them and people don't work for it.... I think the key to man's success on Earth as well as in space is that we have to make these things user-friendly....

There are places that you have to send robots, like the surface of Venus. I'm not sure that will always be the case. But I'll guarantee you, if you put a human being on Mars or Venus right now, you'd sure learn a lot more in a lot shorter time than you'd ever learn with the fanciest and most expensive robot. I think we ought to keep in mind that we can technically do that right now. It would cost a lot of money to do it, but we could sure learn a lot in a short time.

Technolog: As chief of the Astronaut Office, what advice can you give to college-age men and women who want to work in space, either as pilots or as astronauts?

Young: I recommend they just hang in there doing what they're doing. It's kinda luck right now to get into the space program. I don't think it will be in another 20 years. I think a lot of people will be living and working in space in the next 50 years for sure. So I'd just hang in there and do what you're doing.

I think the most important thing in life is to do something that you enjoy and to make sure that you're contributing whatever work you do, whether you're an astronaut or not. The fact that you end up being an astronaut should just be incidental to what you get out of life.

Technolog: What do you think the future holds for you? Do you expect to be going up in the shuttle again? And what about flying in the space station?

Young: Well, I expect to be working on this program for a long time. Just exactly when I fly again, I'm not too sure about.... It's a lot of fun down here (at NASA). We're working very hard.... We're trying to fly eight or nine space shuttles the rest of this year. We're right up to our armpits in alligators, and it's a lot of fun—we've got new problems every time we turn around. ■

TechnoFlog

By Stephen MacLennan
Alan Hauser

The lumber mill foreman put a newly hired forestry student to work for the summer feeding a circular saw. As the foreman started to walk away, he heard an "ouch!" and turned to see the student looking puzzledly at the stump of a finger. Rushing back, he asked what had happened.

"I dunno," said the boy. "I stuck my hand out like this and . . . well, I'll be damned, there goes another one."

Typist: "But professor, isn't this the same exam you gave last year?"

Professor: "Yes, but I've changed the answers."

Professor: "Well, what did you think of the course?"

Chemical Engineer: "I thought the material was very well covered. Everything that wasn't covered during the quarter was covered on the final!"

While vacationing out west, our two favorite forestry students, Leif and Woody, fell in with a group of cattle rustlers. The long arm of the law soon prevailed, and the judge, having little tolerance for such activities as cattle rustling, ordered that each member of the gang be shot.

As the first member of the gang was being tied and blindfolded, he suddenly yelled, "Tornado!" All the guards ran and took shelter, and the rustler escaped.

Foresters Beware!

As the second criminal was being prepared for execution, he yelled, "Flash flood!" Again, all the guards took cover, and the man escaped.

Now the ever-observant Woody had an idea. He glanced at Leif and whispered, "Get ready to run. I think I know how to get us out of this mess."

As the guards were preparing the two for the firing squad, Woody slyly looked at the guards and screamed, "Fire!"

Pilot to M.E.: "What is our present position?"

M.E. to pilot: "Due to my extensive training in calculus and trigonometry, I have calculated our position to be seven miles south of infinity."

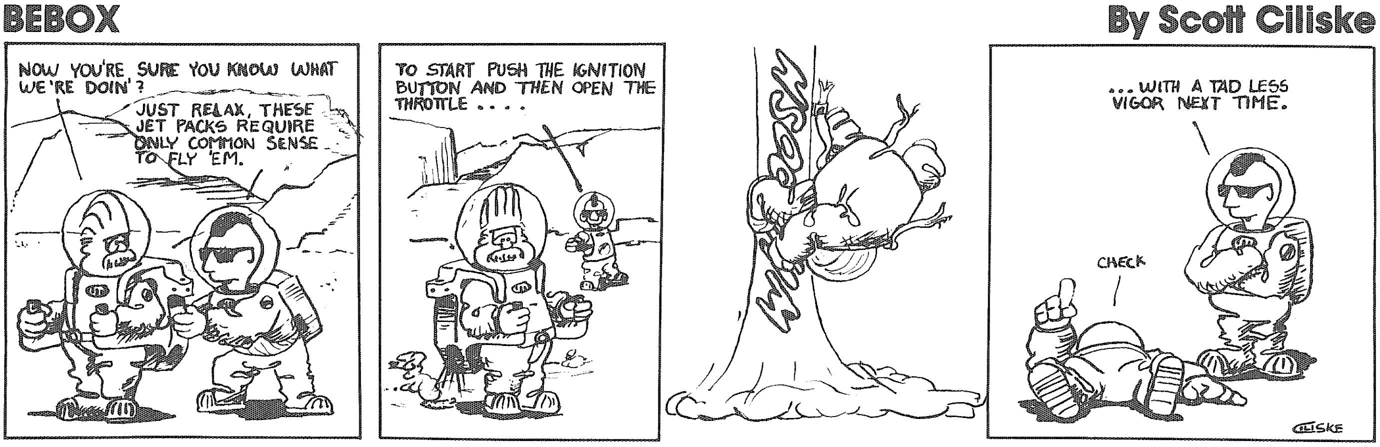
Professor: "Tell us what you know about nitrates."

Chemical Engineer: "I don't know much about them except that they're cheaper than day rates."

Did you hear about the forester who tried to blow up a bus? He burned his lips on the exhaust pipe.

BEBOX

By Scott Ciliske



Brain Teaser

A professor decided it was time to find out what the class had learned. He announced on Friday, "Next week we will have one surprise quiz. You won't know which day it will be given until during class on that very day."

Don was depressed as he left class—he strongly disliked surprise quizzes. Just then his classmate Mary came by with a wide smile on her face.

"Don't you see, Don? We can't possibly have a quiz next week! Let me explain. The professor can't give the quiz Friday. Friday is the last day of the week. By Thursday evening we wouldn't have had the quiz, and we would know for sure that the quiz would be Friday, contrary to the professor's claim that it would be a surprise."

"So what?" replied Don, rather skeptically.

"Friday is then out," proceeded Mary. "Thus Thursday is the last possible day the quiz can be given. But if we haven't had the quiz by Wednesday night, we'd know it would be given Thursday or Friday. Since Friday has been ruled out, we would know for sure the quiz would be given Thursday, again violating what the professor said. Thus Thursday is out, leaving Wednesday as the last possible day."

"I see it now," said Don, showing more interest. "In the same way we can eliminate Wednesday and Tuesday, leaving only Monday. But he can't give the quiz Monday because I know it today!"

Greatly relieved, Don and Mary enjoyed a carefree and study-free weekend. Then on Tuesday the professor gave a pop-quiz, leaving Don and Mary totally surprised. The professor's announcement of the pop-quiz is now seen to be perfectly correct.

What, if anything, was wrong with Don and Mary's reasoning? Come into Room #2, Mechanical Engineering, and tell us your ideas. ■

Technopuzzle

By Mark "Dr. Death" Stolzenburg
Dastardly Dan Rader
Becky "The Beast" Lee
Al "The Hangman" Hauser

Mission Improbable

Good morning, Mr. Phelps. As you are well aware, a group of terrorists, under the evil leadership of the notorious Dr. Death, are currently trying to disrupt and overthrow governments around the world in the hopes that Dr. Death himself will someday rule the entire planet with an iron fist. Recently one of his "Death" squads abducted the city of Cleveland. The president is now trying to decide if he wants it back. If he should decide that he does, a bleak task lies ahead of you. It has been determined that Dr. Death will not release Cleveland unless someone solves the enclosed crossword puzzle. The puzzle has been analyzed by the CIA, the FBI and NASA. All failed, although the FBI said they really didn't try very hard.

Your mission, Jim, should you decide to accept it, is to solve the crossword puzzle. Double agent and aerospace engineering student Daniel Shegitz was able to crack Dr. Death's last puzzle and claimed his very own "Do I.T. with an Engineer" T-shirt. A similar reward awaits the first person to infiltrate Room #2, Mechanical Engineering, with a correctly completed Technopuzzle.

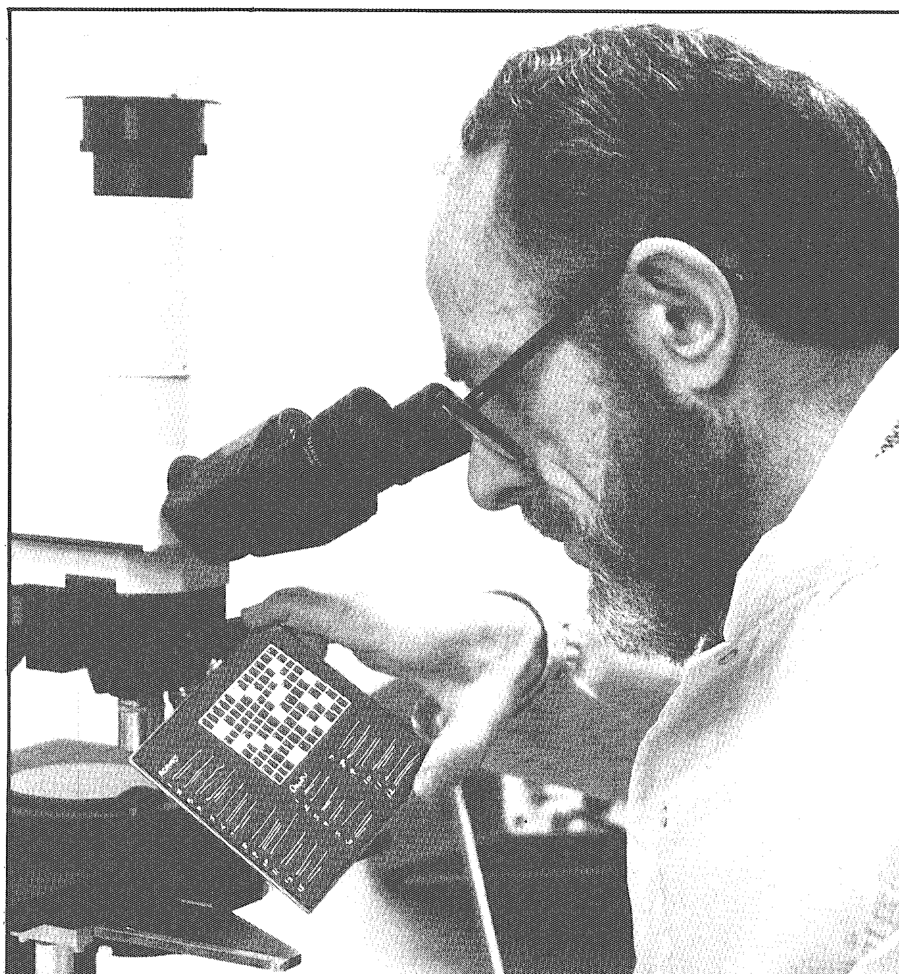
One last piece of information, Jim. Our international ring of informants, snitches, and narks has determined that the puzzle clues and words are related to the subject of space and space exploration.

If you or any of your I.T. colleagues should be caught or killed, the secretary will disavow any knowledge of your actions . . . and, of course, cancel your paycheck. This message will self-destruct in about 100 years, since it is expected that each and every *Technolog* is saved by its owner for the reading pleasure of future generations.

Good luck, Jim.

Spring 1 Technopuzzle solution

1 S	2 H	3 A	4 F	5 T	W	6 O	7 R	8 K	■	9 M	10 I	11 S	E	12 S
13 T	E	N	T	H	■	14 L	U	G	15 B	O	L	T	■	E
16 R	L	■	■	R	■	17 D	B	■	18 L	T	■	19 R	20 A	N
21 A	I	22 R	C	O	23 N	D	I	T	I	O	24 N	E	R	S
25 I	C	E	■	26 W	E	A	K	■	27 P	R	E	S	■	O
28 N	E	O	L	O	G	Y	■	29 A	■	30 C	O	S	■	R
31 E	S	C	■	32 U	S	S	33 A	R	K	A	N	S	34 A	S
D	■	35 C	36 O	T	■	■	37 N	E	■	R	■	38 T	N	■
■	39 T	U	R	B	40 I	41 N	E	■	42 P	■	43 O	R	D	■
44 T	H	R	E	E	B	A	R	L	I	45 N	K	A	G	46 E
47 O	E	E	■	48 A	E	R	O	■	49 N	O	■	50 I	A	N
51 N	O	N	52 B	R	A	K	I	53 N	G	■	■	54 N	T	■
55 A	R	C	H	I	M	E	D	E	S	56 S	57 C	R	E	58 W
59 L	E	E	■	N	■	D	■	O	■	60 S	A	E	■	E
■	61 M	S	■	62 G	C	■	63 U	N	L	A	D	L	E	D



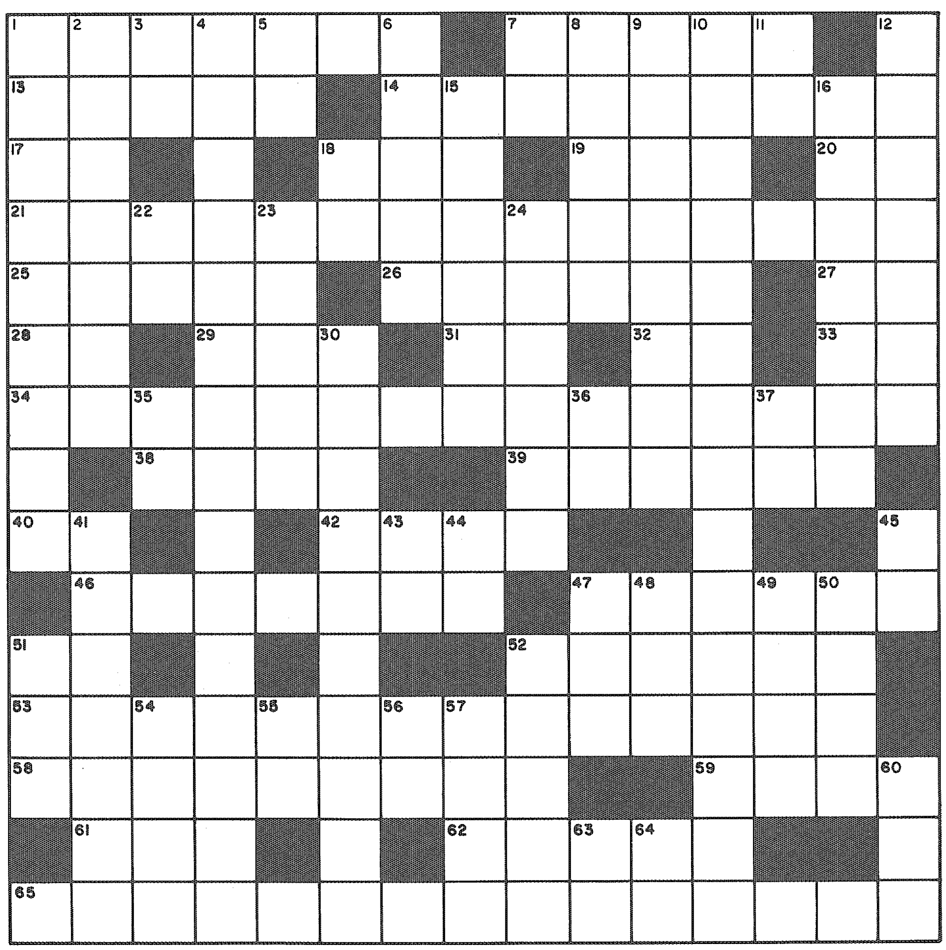
Space Race

Across

1. Spurred U.S. space program
7. Number of ancient "planets"
13. Younger (ant.)
14. Spacey "science"
17. Follows sol
18. Barred from Olympics
19. Architectural angle
20. Circuit time constant
21. Universal
25. Inner skin
26. Music to the ears of a tapdancer
27. NORAD headquarters (abbr.)
28. Pedestrian measure (abbr.)
29. External (pref.)
31. Future shuttle pad (abbr.)
32. Home of *Technolog* (abbr.)
33. Clean-up duty (abbr.)
34. Down-to-earth Americans
38. Dipper
40. Large (abbr.)
42. Lofty agency (abbr.)
46. Almost as good as goals
47. Local astronaut
51. For whom Death waits
52. Do's (ant.)
53. Flight coordinator
58. Element named for planet
59. Stain
61. Direction (abbr.)
62. Famous canine
65. Celestial "fallout"

Down

1. Blast-off shuttle power
2. "Wanderers"
3. UnderDog (abbr.)
4. Data transmission network
5. Natural resources (abbr.)
6. 24 is pure
7. Ordinal suffix
8. Upright
9. French writer
10. Planetary path
11. #
12. Monocular monster
15. Comfort
16. Blackbird
18. Movie rating
22. Presidential initials
23. Human breeds
24. e.g. linguine (2 words)
30. Near Mach I
35. Precious metal (abbr.)
36. Ordinal suffix
37. Boozer's buddy (abbr.)
39. A case, covering or sheath
41. 17th century astronomer
43. In place
44. Adolf's bodyguard (abbr.)
45. Home of 47 across (abbr.)
47. Negative (pref.)
48. A Tolkien tree person
49. Harrier-type aircraft (abbr.)
50. Scandinavian capitol
51. Hearing aid
52. Condition of Twins
54. Stars
55. Moon of Jupiter
56. Coin metal (abbr.)
57. JFK crisis
60. Result of 65 across
63. Atomic number 28 (abbr.)
64. "Yes" in 50 down



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