# Engineers' Forum

VIRGINIA TECH

FEBRUARY 1984

Engineering Research at VA TECH

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# Engineers' Forum

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On the Cover:The Swiss Alps above the town of Lauterbrunnen.*Photo by David Smith.*

# An Overview of Engineering Research at Virginia Tech

*by Pam Bridges*

Engineering research has grown tremendously in recent years. As more knowledge is gleaned dealing with the general laws of matter and energy, applications of these principles are expanded through engineering research. In time, there are even applications as complex as man-made systems and tools of modern technology to expand both present knowledge and the capabilities to continue to expand this knowledge.

Research at Virginia Tech has grown in leaps and bounds over the past few years. The following statistics, compiled by J. Osborne, Associate Dean of the College of Engineering, and the succeeding paragraphs, which present brief outlines of research in each department, do not begin to cover the magnitude, diversity and growth of research in the College of Engineering. These words serve only to increase awareness and appreciation of the vast amount of research activity going on in the College of Engineering at Virginia Tech.

College of Engineering sponsored research activities have increased dramatically over the last ten or twelve years. In fiscal year 1969-70, approximately 80 research proposals were submitted, with expenditures totaling $800,000. During 1982-83, more than 430 research proposals were submitted, with expenditures of $9 million. This figure represents about 25% of total research expenditures recorded by Virginia Tech's eight colleges.

During 1982-83, the College of Engineering earned $2.4 million in research overhead funds which was nearly one-half of the total $5.1 million earned by the eight colleges. A portion--one half--of these $2.4 million in overhead monies are returned to the college and the academic departments and are used in large part to construct, renovate and equip laboratories, thus assuring that both undergraduate and graduate students have access to some of the most modern and sophisticated research equipment and facilities available anywhere.

More than 200 engineering research proposals were funded during 1982-83, with the average value of funded proposals exceeding $50,000. The bulk of this funding was provided by federal government sponsors, headed by NASA ($2.4 million), DOE ($2.0 million), Bureau of Mines ($1.0 million), NSF ($0.9 million), ONR ($0.8 million), ARO ($0.4 million), and AFOSR ($0.3 million). Industrial research sponsorship also increased significantly with IBM, ARCO, General Dynamics, and Bendix each funding more than $100,000 of engineering research during 1982-83. Other industrial sponsors included such well-known companies as GE, Union Carbide, Allied Corp., Phillips Petroleum, Westinghouse, 3M Company, Hewlett Packard, Westvaco and Newport News Shipbuilding.

When naming the engineering departments at Virginia Tech, **Agricultural Engineering** is often omitted; while the engineering degree program is in the College of Engineering, the department itself is administered by the College of Agriculture and Life Sciences. Furthermore, research, extension and teaching faculty, except those involved with the engineering program, are in the College of Agriculture and Life Sciences. This separation is due mainly to the nature of research in the department. Much agricultural engineering research is cooperative research, based on a commitment to the federal and state governments. Indeed, the major goal of agricultural engineering research is to "provide the engineering research results that meet the needs of agriculture in the Commonwealth of Virginia and the nation." While the government mandates a large number of research projects through federal agencies such as the Bureau of Mines, Dept. of Energy and the National Forest Service, private industry, John Deere, for example, also provide support for research.

Areas of research in the department are energy-source development, management and conservation,water and soil, and facilities and procedures for production, transportation and storage. Research projects in these areas range from utilization of wind energy for cold storage of apples to measuring rainfall through microelectronic controls. One current project calls for the optimization of efficiency of energy use for on-farm drying and processing of agricultural products such as peanuts. Another project involves verification of a statistical model for the tensile strength of various grades and sizes of structural lumber.

These two projects indicate only a small portion of the research conducted in agricultural engineering. Much, much more is being done to better agriculture in Virginia and the rest of the United States

Research in the Department of**Aerospace and Ocean Engineering** has grown tremendously over the past few years. The department had over $750,000 in funded research projects in the 1982-83 fiscal year, with the amount expected to increase dramatically this year. Many projects are supported by NASA and involve aspects of space travel, structural optimization of aircraft, and vehicle stability and control. Methods of research include mathematical models and actual experimentation often utilizing the department's 6 ft. by 6 ft. wind tunnel.

One interesting project conducted with analytical and computational methods is the formulation of collision-avoidance and air-to-air combat situations as differential games. A project that involves numerical solutions and wind tunnel model applications focuses on propeller and windmill flow-field studies.

Another project currently of interest is directed toward the design of reentry vehicles such as the space shuttle. The approach taken in this project is the simultaneous design of the structure and thermal protection system. This could require thicker insulation, lower temperatures and a lighter structure to better integrate the structure and heat resistance methods.

While the number of full-time faculty in the **Department of Chemical Engineering** is small, being only 15, the amount of research accomplished is large. In the 1982-83 year $498,000 was put towards research in the department. Releative to this information is the fact there is much more research-joint research-being conducted by members of the Chemical Engineering Department in conjunction with other departments. For example, the Polymer Interface Laboratory, co-directed by Dr. Garth Williams and Dr. McGrath (of the Chemistry Department) combines a number of departments and its funding is at least equal to Chemical Engineering's total departmental funding.

Several diversified areas are being dealt with in Chemical Engineering research at the present time. Much work is being done with polymers-natural and syntheric compounds consisting of up to millions of repeated linked molecular units-and their property behavior and structure. For example, studies are being done where polymers can be created to substitute for other materials-another synthetic polymer or natural substance such as wood.

One current Chemical Engineering research project deals with the creation of new methods of production of pharmaceuticals-mainly penicillin and other antibiotics. Another involves studies of various methods of in-situ biological treatment of hazardous organic wastes in a spill or impoundment situation.

As in other engineering fields, research work in Chemical Engineering is also being completed utilizing computer analysis and modeling to optimize systems and procedures.

Research in the **Civil Engineering Department** falls under several areas, Structural, Hydrosystems, Transportation, Geotechnical, Geodectic and Environmental Divisions.

Some sponsored research projects in the Structural division include evaluation of resonance frequencies of shell structures subject to fluctuating forces ( applicable to soft drink can design and football stadium roof stability subject to excess weather conditions). Also in the Structural division, work is being done involving the development of software to integrate the most efficient analysis and design techniques available for structural engineering evaluation.

In the Hydrosystems division funded research projects include comprehensive state water resources planning and other hydrology, hydraulics and water resources engineering projects. Also, studies are being conducted on the Coal Slurry pipeline to transport coal to the ports of Hampton Roads from southwest Virginia coal mines. The hydraulics of the water and coal mixture in the pipes, the amount of water necessary and the environmental issues are all factors in the studies.

Evacuation plans are a major topic of research in the Transportation division. In general, work is being done to determine the shortest, safest routes to be utilized to best connect traffic generating points and shelters in the event of a natural disaster. One specifiec example is a hurricane evacuation plan for the city of Virginia Beach.

Geotechnical engineering deals with the earth-literally-and involves work with soil and groundwater. Subjects dealt with are the development of new methods to test soil strength, containment of hazardous wastes by subsurface burial, and tunneling and excavating technology.

Geodectic engineering does research in surveying, photogrametry and geodesy. Often computer programming and electronics are integrated in projects to more precisely measure distances and aid in image processing.

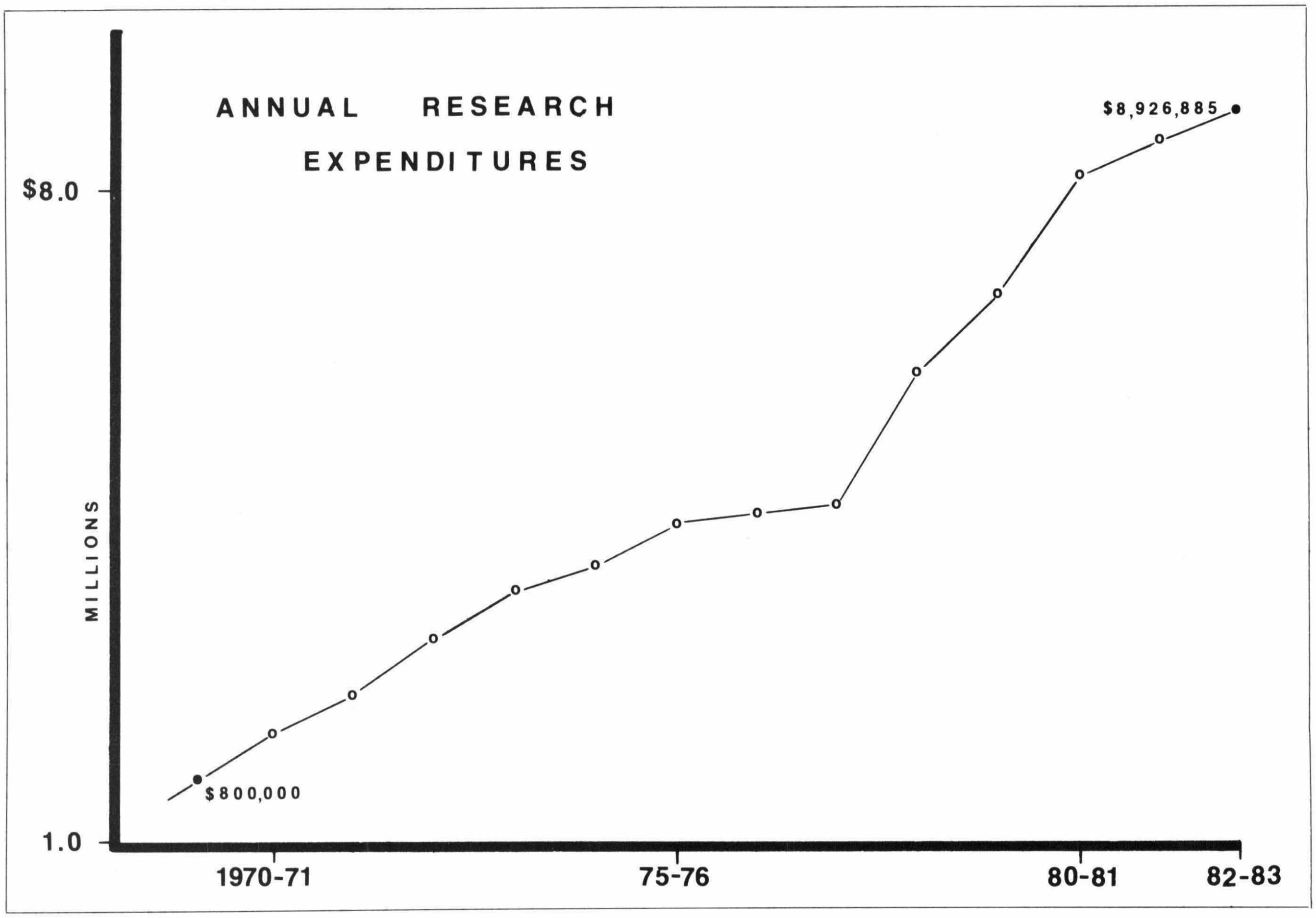
The Environmental division of the Civil Engineering Department has current research projects related to the treatment of toxic wastes, the increased understanding of air quality factors and the reduction of pollution from stormwater runoff, dealing most notably with the chemical-physical reactions between soil and pollutants.

With the value of research proposals funded almost tripling from the 1981-82 to the 1982-83 fiscal years in the Civil Engineering Department, research can be expected to continue to grow in the department in the coming years.

With total funding of 4.5 million dollars for active externally funded research projects during the 1982-83 and research expenditures close to 1.5 million dollars the past few years, the **Department of Electrical Engineering** is involved in many large, ongoing research projects. The graduate study program and research assistantships as well as research laboratory facilities in the department greatly enhance the research program in Electrical Engineering. Laboratories include the Applied Solid State Science Laboratory, utilized for studying both the electrical and optical properties of thin-film semi-conductor devices, a satellite tracking station, used to study the lower atmosphere and its effects on electromagnetic signals, and the Spatial Data Analysis Laboratory, which supports such work as computer art, spatial and geographical image processing, and robotics. Facilities also include three computing systems (part of the University Computing Center), a microcomputer laboratory, several small digital computers and a hybrid computer system to aid in graduate work in computer engineering, simulation and digital control.

Research activities are diversified-ranging from image processing and robotics vision to satellite communications to power systems. Much of the research is supported by NASA and the National Science Foundation, while some, such as the study of the impact of energy management on the consumers of electrical energy in Virginia, are sponsored by organizations like the Center for Coal and Energy Research. These projects and others the department is involved in utilize (and sometimes create) much state-of-the-art electronic and computer equipment and technology.

The research program in the **Engineering Science and Mechanics Department** is one of the largest and most productive of its kind in the nation. During the 1982-83 fiscal year, the department was awarded 43 new projects, increasing its total number to more than 70. The research projects provide financial support to approximately 70 graduate students and salary support to about 30 faculty members each year. Funding has been provided by the **DOD agencies, NASA, NSF, DOE, several industries and**




private foundations. During the 1982-83 year four ESM faculty were bestowed with major research awards by the American Institute of Aeronautics and Astonautics, American Society of Civil Engineers and Society for Experimental Stress Analysis.

Some general areas of current research and interest include: solid mechanics, fluid mechcanics, composite materials, biomechanics, and finite-element studies. One current project utilizes computational methods for the control of higher-order systems. This research intended to develop technology applicable to the control of large space structures. Another investigates a new method of characterizing dynamic response of materials to applied loads. Defects, such as cracks, are detected using a thermographic camera to view heat energy dissipated by materials applied with loads.

With the growth in research activities and the fine faculty in the department (exemplified by the fact that three ESM faculty members have received the VPI&SU Alumni Research Award in the past several years), it can be expected that the Department of Engineering Science and Mechanics will continue to exhibit excellence in research activities.

Research in **Industrial Engineering and Operations Research** has made impressive strides in the past several years. The department has recorded a 92% increase in research expenditures during the past four years and that number is still growing.

Research in the department falls under four main areas: human factors, operations research ,and manufacturing and management systems. In the human factors area, one current study deals with the relationship between productivity and alcohol. Criteria such as quality, production time and safety are considered in the evaluation of various types of industrial tasks performed with varying degrees of blood-alcohol.

The Management Systems Laboratory deals with ill-defined problems involving severe consequences such as emergency situations. Presently, research includes the development of emergency plan models and emergency information systems. These accentuate the human interface needed by managers when dealing with a crisis situation. The laboratory works to provide structured communication networks for the organizations it works with, allowing better information flow in both emergency and normal operations situations.

A Flexible Manufacturing Systems Laboratory is one of the interesting components of the manufacturing systems area. It is a miniature automated factory used for instruction and research and contains two scaled milling machines, two robots, and a miniature automated storage and retrieval system.

Two "modeling" applications utilizing computers and mathematical abstractions of physical systems involve the reduction of airport noise using variables such as altitude and direction, and optimal manufacturing processes for mass-produced electrical components.

The research program in **Materials Engineering** involves several aspects of the development, manufacture and application of engineering materials to include metallic materials, ceramic materials, polymeric materials and electronic materials. Sponsored research activities include: investigation of the effects of hydrogen on metal alloys, economics of materials processing and materials utilization, the physical and chemical nature of surfaces and interfaces in engineering materials, and thermo-chemical behavior of high temperature structural materials for applications such as diesel engines.

Research programs are sponsored by the Dept. of Defense, NASA, the National Science Foundation, the Dept. of Energy and a number of industrial corporations, such as the Aluminum Company of America.

Highlighting some research activities in the department, one current project deals with refractory materials and high temperature phase equilibrium. This particular project involves the development of refractory coatings for the graphite reinforcement fibers in carbon-graphite composites used on the NASA Space Shuttle. The objective of this work is to develop a coating which allows the two phases of carbon to be chemically compatible at high temperatures during shuttle re-entry, and so that the composite will be resistant to oxidations.

In another example, research is concerned with the physical and chemical properties of surfaces in multiphase engineering materials, including composites, bonded structures and thin-film systems. Applications can be divided into two categories; the first deals with failure analysis and the precise determination of micromechanisms that lead to fracture while the second involves surface modification--tailoring new surface structures and properties by using block copolymers or ion bombardment.

A final example focuses on the environmental degradation of engineering materials. The general objective of this research s to develop means whereby available engineering materials can be utilized in aggressive environments, such as hydrogen or in other media which corrosively attack engineering materials. Facilities and equipment for this research include high pressure hydrogen test facilities and associated autoclaves and furnaces and hydrogen handling systems to permit long time exposures to high pressure high hydrogen.

The research program in **Mechanical Engineering** includes a wide range of topics. In generic terms, the research projects cober acoustics, biomedical devices, combustion, computer aided design, mechanical systems analysis, nuclear reactors and robotics.

The work includes both theoretical studies and experimental investigations. Some examples are the development of computational methods, which is entirely analytical, and the measurement of the burning rate of solid propellants, which involves sophisticated measuring techniques.

The research is supported by extensive laboratory facilities which include a wide variety of specialized equipment and state-of-the-art instrumentation. The most recent addition to the laboratories is a two million dollar computer system which was given to the department by IBM to expand research efforts in computer-aided design and computer-aided manufacturing.

The current rate of expenditure for research is approximately one million dollars per year. This support comes from a number of government agencies and approximately twenty-five percent of the funding is from industrial sources.

Research projects in the department cover a wide variety of subjects. Work is being done with engines, to create alternate fuels and better understand such topics as bearings and rotor dynamics. In biomedical research, projects include the development of a closed-loop control system for a blood pump and blood oxygenator and the integration of microporcessor systems and medical instrumentation. Projects dealing with breeder reactors include the design study of heavy water breeder reactors and the invention of a supersafe breeder reactor.

And in the up-and-coming field of robotics, work is being done in the locomotion and design of robots and their driving software and control. These mentioned topics indicate the wide variety of subjects being explored in Mechanical engineering research.

In 1982, a Generic Mineral Technology Center, Mine Systems Design and Ground Control, was awarded by the Office of Mineral Institutes, Bureau of Mines, Department of Interior, to the **Department of Mining and Minerals Engineering** ,VPI and SU, with six participating universities-Alabama, Alaska, Idaho, Kentucky, Nevada-Reno, and Va Tech. Because the department has pursued pioneering sponsored research in mine systems design and ground control for the past twenty years under continual sponsorship by the Office of Caol Research, the Department of Interior, the Energy Research and Development Administration and the Department of Energy, the first annual grant of $1 million has permitted principal investigators and graduate students with the department to pursue two research projects concerning rock mechanics and ground control, one project on computer modeling and simulation of mining systems.

General areas of research include exploration, evaluation development, extraction, conservation and the environment, mineral processing and mineral economics. In the area of mineral processing the objective of the research is to separate the valuable minerals form host rock materials that are mined by utilizing primarily chemical and physical means. Efforts in the department include processes for cleaning coal, refining procedures for various sulfide materials and optimization of the performance of plants for mineral processing and coal preparation by use of computers.

Other projects in the department include studies of parameters, controlable and uncontrolable, which may lead to improved management of unstable roof conditions in the underground coal mines of Central Appalachia, utilization of interactive simulation with digital computers performing an optimization and integration of ground-control theory and systems engineering parameters in the underground mining of coal.

A substantial amount of research effort in this and other departments has been pursued in advance because the uniques possibilities of the computer and othe state-of-the-art tools have been brought to bear on the difficult and complex quantitative problems in engineering research.

# HIGH QUALITY

## The College of Engineering

*by Debi Matthews*

The Virginia Tech College of Engineering is one of the premier engineering colleges in the nation. Not only is the college acclaimed for its impressive faculty, research programs, and modern facilities, but is also noted for the high quality of students chosen for admission into its program.

Upward of 5,000 applications were received for the 1983-84 school year, of which only 1,150 were chosen for the freshman class. This year's figure for the entire undergraduate Engineering College enrollment is 5,174; in addition, there are 790 graduate students. These enrollments allow the College of Engineering to comprise about 28 percent of the university total.

Admission is highly competetive. The average SAT score for this year's entering freshman is 1,211, compared to those who entered last year average 1,206; the 1981 admittees with 1.180; and those who were admitted four years ago having an overall average score of 1,177. As the years progress, so does the degree of competition.

Seventy-nine percent of Tech's freshmen graduated in the top 10 percent of their high school class; 31 percent of which were president or vice president of a student organization. Comparably, the United States Air Force Academy, also noted for its excellence and leadership, this year had 69 percent of it's cadets graduating from high school with honors, of which 21 percent were leaders of student organizations.

Statistics show that a substantial amount of Virginia Tech's engineering students were active in high school athletics, band, or yearbook publications, suggestive of the well-rounded individuals that have been accepted into the program.

The freshman engineering curriculum is geared to help students choose one of Virginia Tech's department specialties, with courses in introduction and general engineering, calculus, chemistry, physics, English, and computer programming, in addition to a few electives.

The 1984 freshman program will include the IBM PCjr. It is recommended that each student purchase an IBM PC jr and related software with a two year financing option.

More than 1,600 of the small personal computers have already been ordered for faculty members and the September '84 freshman class. Tech will also purchase 90 IBM large personal computers for three new computer labs to be located in academic buildings.

Virginia Tech is the first major public university to strongly suggest that its engineering students purchase their own computer. The program is already in effect at small private colleges like Drexel University, Pennsylvania, and Clarkson College in New York. The PC is a progressive step for Virginia Tech, but a necessary one in order to maintain a modern curriculum and a competitive position in engineering excellence. A survey reports that 80 percent of this year's freshmen had school or home computer experience prior to admittance, (up 20 percent from last year's entering class). The computer is quickly becoming a major part of modern engineering.

Virginia Tech's College of Engineering has a large and highly regarded faculty, and numerous government and private research contracts.

A national survey has ranked VPI along with MIT, Berkley, Standford, Cornell, Purdue, U of Michigan and Georgia Tech as having produced from undergraduate school the most successful participants in graduate programs at various schools across the country. Last year 992 bachelor's degrees were awarded, nearly double the figure of six years ago; 225 graduate degrees were awarded in 1982-83.

The Virginia Tech College of Engineering: dedicated to excellence in a highly respected university in the field of engineering. A high caliber fculty, modern facilities, and a progressive curriculum are demanded by the high quality of students enrolled in the program. Yes, be proud.

# The Computer Talks Back!

*by Judy Moore*

In the competetive market that exists in today's industry the demand for productivit y is reaching peak levels. Computers are at the forefront of techniques used to increase efficiency and productivity and decrease time and energy consuming human error. Designing systems of people and machines for safety and efficiency is no simple task. Part of the Human Factors laboratory in Whittemore Hall was designed to study the human/computer interface with these objectives in mind. The lab is equipped with the VOTAN V5000A Recognizer/Digitizer and the Interstate Electronics Voice Recognition Module which are used to investigate the applications of the computer to increase productivity.

Beverly Williges, the senior research associate in Human Factors, is concluding a joint study with the computer science department on computer based voice recognition and synthesis. The Office of Naval Research granted the study three years ago. The Navy is interested in applying the techniques to assist pilots of low-altitude, high-speed aircraft, who cannot look away from the controls yet require additional vital information. Verbal command and response would fill these requirements well.

The project was initiated by a large jump in technology; the hardware became available but human factors engineers had to figure out how to employ it successfully for increased productivity. A prototype device for speech synthesis was available at the University of Illinois Research Laboratory where Ms. Williges worked before coming to Virginia Tech. Here at Tech, she became the task leader for the voice project.

The voice synthesizer can work in two ways. First, it can take a spoken message, digitize it, store the message in the memory of the computer, and repeat it upon request. The quality of this speech varies according to the speed of the message and the amount of memory used. At a high bit rate, the words sound like a high quality recording. At a low bit rate, the words are garbled; it sounds, as Ms. Williges says, "like talking underwater in a tunnel." The main disadvantage to this system is that every message must be prerecorded.

VOTAN 5000A talks to Bev Williges.

The second message employs phonems (basic language sounds) and rules by which they are converted to messages. The accuracy and flexibility of these rules determine the intelligibility of the the message. The drawback is that the message sounds like a series of sounds that are "glued" together. Try calling an old phone number and listening to the recording. This is an example of phonem based speech synthesize.

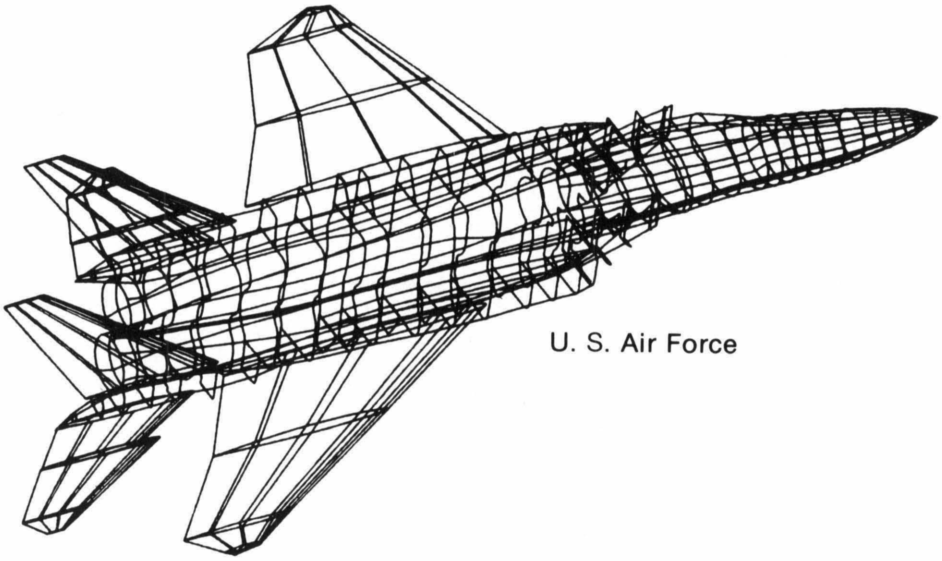
Voice recognition is the complimentary ability of the synthesis device. The computer is "taught" an individual's speech pattern for each word it will "recognize." It must also be taught what response should be associated with the key word. When the speaker addresses the system through the directional microphone, the device matches the word spoken to the words in the vocabulary template. If it finds a match, it performs the associated task, otherwise it does nothing. Although the template can only hold 100-500 words, the recognizer can be connected to a host computer and switch the templates back and forth between the recognizer and the host computer. The system can recognize only one word at a time; thus the operator must speak in "slow motion." Increased interest demanded that connected word devices be pursued energetically, which lead to the development of devices which can handle word strings up to five words long. Software has been added to many systems to help the computer recognize the word by indicating the word most likely to be used after a particular word. The closeness of the word match can be varied, depending on the application, allowing only one individual or virtually anyone to activate the response.

The application of the voice recognition/synthesis devices varies from Navy pilots and national security to medical laboratories and operating rooms to darkrooms and office automation. Low-altitude, high-speed Navy pilots need further critical informatin, yet cannot look away from the flight path for an instant. A voice recognizer/synthesizer could provide the information.


Jayne Schurick dictates to the speech recognizer.

The device could monitor classified radio frequencies and alert human supervisors with visual and audio signals when key words are heard, thus reducing human error in this tedious and critical job. Computers never get bored or sleepy and they always tell the *whole* truth—a vital requirment for national security. The recognition device could assist in medical laboratories, operating rooms, drug companies, and forensic laboratories with the large vocabularies of technical terms it can handle accurately. The photographic darkroom causes specific problems because of the requirements of darkness, liquids and chemicals. The voice recognizer eliminates the need to push keyboard buttons and to decipher the visual response in the dark. The Japanese have an application in office automation. With thousands of basic symbols, the keyboard as we know it is not feasible. Currently, each symbol must be hand chosen and placed in order to be printed. If office workers could go from verbal messages, through the circuitry to the printer, this time- and energy-consuming activity could be eliminated. Productivity would be increased tremendously. These and many other applications are being studied in the Human Factors lab. Industry has quickly put the system into practice and invested in further research.

The problems have not been totally eliminated; cost is still high and technical problems still complicate the procedure. Voice synthesization/recognition holds promise however, to eliminate boring and tedious aspects of some jobs, to fill in places where humans cannot be accommodated, and to increase efficiency and productivity in many applications.



U. S. Air Force

# The Human Factor

## *Tech Professors Study Technology's Limit:*

*by David Thompson*

Over the Mediterranean Sea, an F-14 on maneuvers screams by another plane. The mission: a mock battle. The jet's pilot pulls hard on the stick as he turns and ascends in one smooth motion. The plane, capable of withstanding 10g's, is nowhere near its limit. The pilot, however, blacks out on this 8g maneuver. His plane, now out of control, hurtles toward the water at a speed greater than twice the speed of sound.

In Alaska, another pilot makes an emergency landing in a remote, northern section of the state because of an electrical failure. While removing the emergency survival gear from the plane, he realizes that the temperature is dropping and the wind is picking up speed. He wonders if he can stay warm long enough to survive until a rescue party can find him. Hours later, with wind chill factor at -40 C, the search party finds his frozen body in the plane.

These fictional scenariaos are too realistic, too possible to be ignored. Consequently, the Navy conducts a great deal of research that focuses on

**His plane, now out of control, hurtles toward the water.**

the performance of the human body under extreme circumstances such as under acceleration or cold conditions. Initially one might jump to the conclusion that such research is conducted entirely by physiologists and M.D.'s. The Navy, however, knows that for the study of such problems it needs researchers with an understanding of the laws of physics and systems analysis. In other words, the talents of engineers—specifically biomedical engineers, are required. Biomedical engineers have the special combination of medical and engineering knowledge necessary to study such problems. Consequently, the Navy has employed the talents of two Virginia Tech biomedical engineers: Professors J. Wallace Grant and Daniel J. Schneck. Both had summer fellowships with the Navy this year.

Professor Grant worked at the Naval Air Development Center (NADC), north of Philadelphia where he studied the effects of acceleration on blood flow to the brain. Modern fighter jets can maneuver at extremely high levels

Dr. J. W. Grant

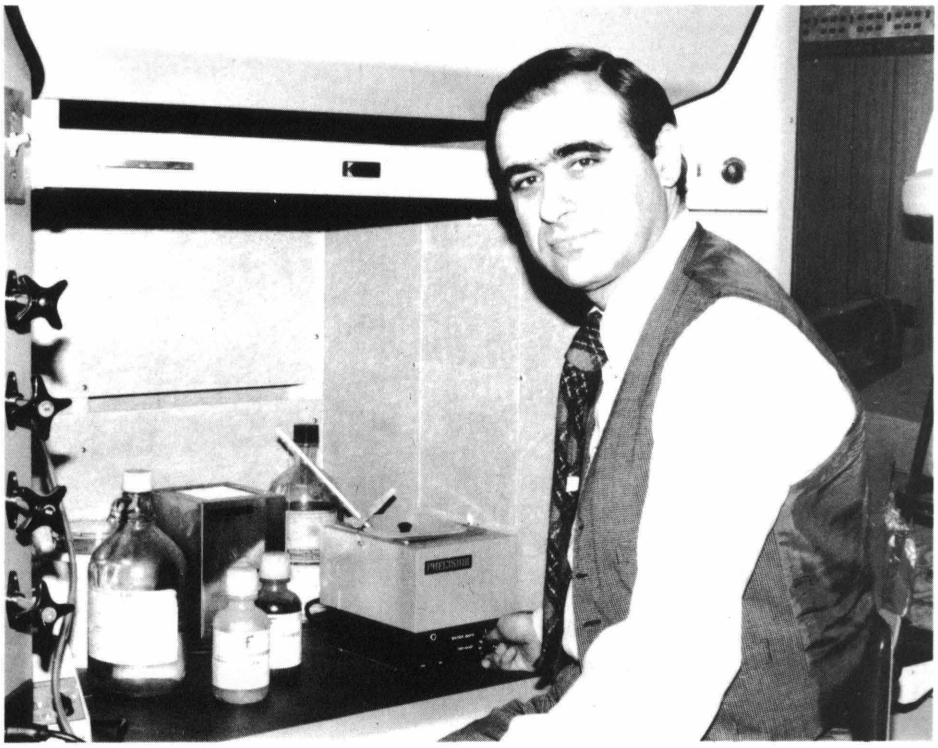
of performance. The limiting factor with respect to a plane's effective maneuverability is the pilot and nct the aircraft. Without special clothing, an average pilot will black out around 3g's. Special "g-suits" increase this limit to around 8g's. Understandably, the Navy would like to improve upon this so that its pilots can safely fly closer to the limits of their planes.

At high g's, the heart pumps harder to compensate, but there is a time delay in the compensatory effect. Because of this delay, the onset rate of acceleration (g's/sec) is at least as important as the maximum acceleration experiences. It is extremely difficult and dangerous to measure the blood pressure to the brain directly, so Doppler flow meters, which use ultrasonic waves, measure the velocity of the blood flow to the brain. These devices are connected to a transducer near the superficial temporal artery above either eye. Prof. knowledge of thermodynamics enabled him to systematically design be misleading. At high g's, arterial pressure at brain level is reduced, and as a result, the arteries contract. This arterial contraction produces increased blood velocities at reduced flow rates. Prof. Grant's knowledge of physiology and fluid dynamics enabled him to understand the phenomenon and predict from the blood velocity and the acceleration the actual volume flow rate of blood to the brain. Being able to do this is important in testing ways to reduce the possibility of a pilot blacking out.

Prof. Schneck worked at the Naval Medical Research Institute (NMRI) in Bethesda, Md., and studied the effects of the rapid onset of extreme cold on the human body. In a cold combat situation, the adverse effects of cold stress on the cardio-vascular system become manifest in decreased performance. The cardio-vascular system must regulate body core temperature within a very narrow range in order to sustain life. Normal body core temperature is 37 C, but at 30 C, the individual is usually dead. The Navy would like to be able to prevent loss of life of pilots such as in the scenario above due to cold stress. Approaching the body as an engineering system, Prof. Schneck has developed criteria to use in screening personnel to distinguish between those able to withstand cold and those susceptable to cold stress. He has also set forth protection requirements and helped design some of the protective gear the Navy is presently testing. He found heat transfer characteristics of clothing as well as its location are important factors to be considered. His knowledge of thermodynamics enabled him to systematically design clothing to protect one from cold. In addition, Prof. Schneck helped develop means by which an individual can generate more heat and withstand cold more effectively. This means special exercises and training techniques reating the human body as an intricate electromechanical engine.

The biomedical engineers are working toward the establishment of an enviromental stress institute here at Virginia Tech. Such an institute would allow Virginia Tech faculty to conduct critical biomedical research without taking leave from the university, thus maximizing the unique faculty resource at Tech.

Dr. D. J. Schneck



# MQ: The Misery Quotient

*by Erann Gat*

Would-be engineers lead the happiest lives on campus. When you have a Deformables test on Tuesday with Engineering Economy formulas fighting Physcis equations for equal rights, you just don't have *time* to be miserable. But take heart; help is on the way. A research team in the department of Engineering Science and Mechanics in a recently completed study has developed several methods by which an engineering student may partake of the misery and suffering enjoyed by other majors, and still keep up with his or her work. The importance of this study should not be underestimated: in one swell foop the ESM department has solved two of the great engineering problems of our time, namely, 1) how does an engineer do his work and still enjoy a good healthy dose of misery now and again, and 2) what does and ESM major *do* anyway? This remarkable study certainly ranks among the great technological achievements of our time, comparable to Tang and the electric hot dogger.

Each of the many methods that the report describes is assigned a misery quotient (or MQ) which is a measure of the average resultant misery (in the appropriate SI units of equivalent quaaludes per problem set) divided by the average effort for implementation. Here then is a brief summary:

1. *Use a slide rule:* This time-honored technique has declined in popularity in recent years with the advent of the electronic calculator. But not even Hewlett-Packard's Reverse-Polish notation can compare to the frustration that a good slide rule can produce when properly abused. If this fails to work, you can always remind your professor that he should take off points for improper use of significant figures. **MQ 11.7.**

2. *Take CS2073:* The sheer number of horror stories circulating about this five-hour computer science course should give an indication of its awesome misery potential. Not only do you get to punch program card decks whose heights are measured in meters (or yards if you are a CS major), but you can also enjoy the rapturous frustration of losing your place in the terminal line when after seventeen hours of waiting, your excretory system goes critical. **MQ 79.3.**

3. *Forget your umbrella:* This method works only on rainy days. It is particulary effective when combined with one or more of the following: 1) Do your homework in water-soluble ink; 2) Forget to do your homework; 3) Forget your coat too; 4) Forget your pants; 5) Catch a cold; 6) Take your microprocessor development kit outdoors (EE's only); or 7) Do your laundry. **MQ 19.0.**

4. *Sit in on an EF1010 class:* Find out how little you actually know about isometric projections, graphical integration, and how many cubic inches are in a gallon. If you are an upperclassman, this method will do wonderful things to your ego. **MQ 4.2.**

5. *Change your major to anaerobic microbiolgy:* If this method is to be successful, it is imperative that you do not investigate the employment opportunities until *after* your major is officially changed and your QCA has dropped far too low to change it back. **MQ 227.9** (Note: The ESM department is currently seeking undergraduate experimental subjects for research into the possiblity of extending this method to aerobic microbiology as well. Interested students should apply at the ESM office.)

6. *Visit M.I.T.:* If talking to a twelve-year-old undergraduate genius who knows more than most of your professors doesn't get you down, then seeing the equipment in their electronics lab surely will. Look at their shiny new high-resolution color terminals and think about waiting three hours for a battered Hewlett-Packard in the basement of Whittemore. Cry. **MQ 7.1.**

7. *Go to your engineering economy class:* Everybody knows that Engineering Economy is just sixth grade math, so naturally only a sixth grader can understand it. As you listen to lectures about capital recovery, internal rates of return, cost accounting, and "P given F" factors, keep telling yourself that this is sixth grade math, and especially keep telling yourself that you have to *pass* this course to graduate. **MQ 17.1.**

8. *Figure your taxes:* If you are in life for the money like most engineers,then undoubtedly the thought of an eventual paycheck has kept you chipper through many a mechanics test. But even this pernicious obstacle to misery can be overcome by picking up a 1040 form, imagining what you would like your salary to be, and finally figuring Uncle Sam's cut. **MQ 78.8.**

# Agricultural Engineering

*by Linda Wagnecz*

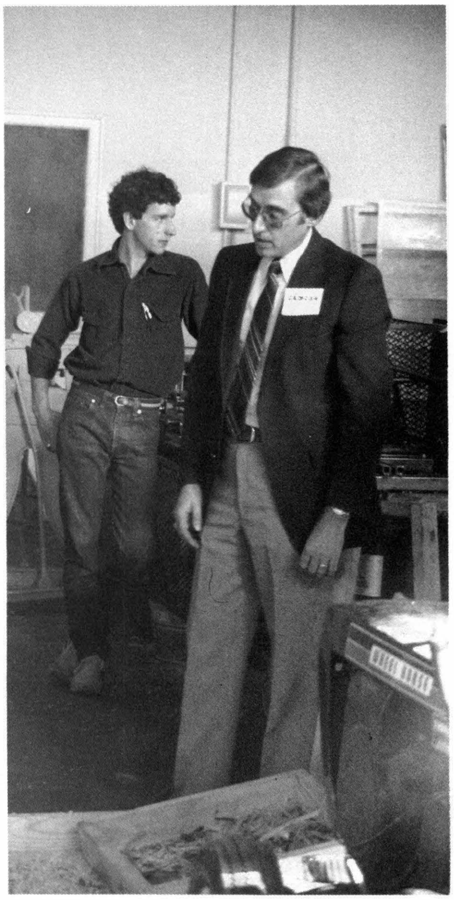
Although agricultural engineers get little attention, they are the ones responsbile for our high standard of living. By increasing the productivity of farms and processing plants, they are able to keep both food and clothing at an affordable price for most people in this country. In order to help those in less fortunate nations, agricultural engineers work with organizations like the Peace Corps to help educate people so they can support themselves one day. Whether working on a foreign or domestic project, an agricultural engineer can be proud to know that he is doing something to benefit society.

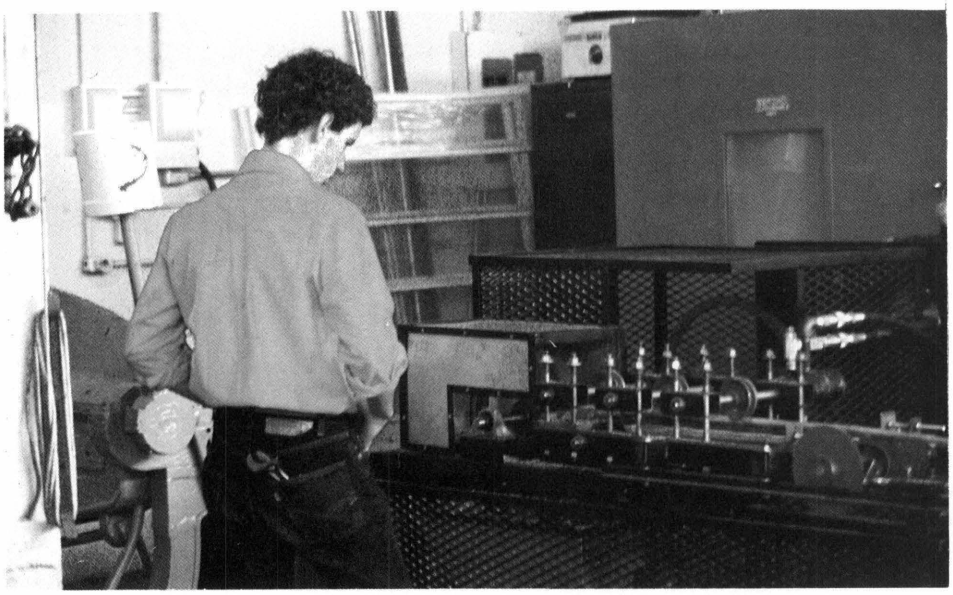
Research in agricultural engineering has one main purpose—to enhance the quality of life. During the energy crisis of the seventies, solar energy was a heavily funded area of study. Today, a new interest exists in computerized farming equipment which can greatly increase production and efficiency. For example, a simple electronic device placed around the neck of a dairy cow can be used along with a sensor and computer to record the quantity and composition of milk collected and to adjust the cow's individual diet to optimize milk production.

Virgina Tech's agricultural engineering department is involved in various areas of research. A lot of work is being done on the environmental effects of surface mining. This type of mining, which has been used in Virginia for nearly a century, uses explosives to blast away top soil to expose coal deposits. After the coal has been removed, a mixture of soil and rock is dumped back into place. Unfortunately, this new layer of soil is usually so altered in composition that it can no longer support vegetation.

A project described by Dr. Magette has resulted in the design and construction of a rainfall simulator. This apparatus, containing a large number of hypodermic needles, can apply water at precise intensity and energy distributions. Using data obtained from the simulated rainfalls, a mathematical model will be constructed concerning the absorbtion and repulsion of water by the disrupted soil. Using these results restoration procedures cn be devised for the soil.

Although the energy shortage is not a big issue today, agricultural engineers are preparing for the future. Two interesting projects examining alternate energy sources are being researched at Tech. Two possibilities are biogas and sorghum.





Biogas, the natural gas given off during the decomposition of organic materials is used extensively in the Republic of China. Simple devices are used to collect the fumes, and not only do they provide "free" energy, but they also cut down on odor and pollution.

The use of biogas has been very successful on a few farms in this country, but mnay others are too small to collect enough organic waste to make the purchase of the equipment worthwhile. According to Dr. E. Collins, as small farms continue to conglomerate into larger ones, and as enegy gets scarce, biogas may one day be a common fuel.

***Continued on page 24***

# A European Education

## Engineering Students Travel to Europe

*by David Smith and Nancy Brooks*

Thirty-six engineering students participated in the 1983 College of Engineering Study Abroad Program. The group, accompanied by Dr. and Mrs. Michael Karmis, left Dulles International Airport on Sept. 1. Arriving in London, the group travelled to Oxford where they stayed at Queen's College, Oxford University.

The students found Queen's College to be much different from Virginia Tech. For instance, servants brought the group a breakfast of cereal, toast, juice, eggs, bacon, sausage, and coffee or tea (not quite like Dietrick' dining hall). The service, however, was not the only difference. Some of the students, having spooned salt onto their corn flakes, soon realized that both salt and sugar were already provided in dishes.

By bus, the students journeyed to Stratford-upon-Avon and then to Bath. In Stratford, they watched the Royal Shakespeare Company's presentation of *The Comedy of Errors.* After the play, students had tea at various local restaurants, while others strolled around the town. The ancient Roman baths in the city of Bath intrigued many

St. Paul's Cathedral,London

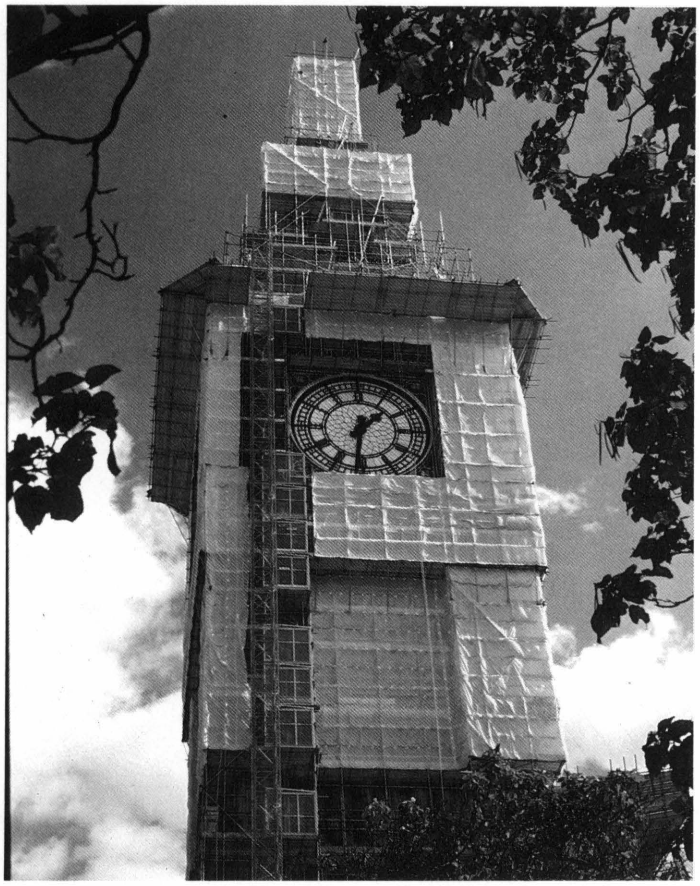
All Souls College, Oxford

students. Some, though, were more interested in a "Battle of the Network Stars" type of competition there that included kayak races and a cricket match.

After three days in Oxford, the group returned to London and checked into Imperial College, London University, from which students visited a number of different sights. Many commented on the size of St. Paul's Cathedral. By means of a precipitous stairway, the students ascended to the dome, where they viewed the city all around. Few skyscrapers for a city of seven million punctuated the horizon.

The Tower of London, once a fearsome fortress, now quietly houses the Crown Jewels and a vast collection of armor. The exhibit of royal treasures features crowns, scepters, rings, and the 530-carat Star of Africa diamond. Weapons from Europe, Africa, and the Orient, including armor for elephants and Chinese mortars, are displayed. One room is devoted to instruments of torture, and the walls of a cell have been untouched to show the carvings of the prisoners.

For those who cannot afford a trip around the globe, the British Museum is the next best thing. Few countries have not contributed to what is one of the largest collections of antiquities in the world. In the early 19th century, Lord Elgin brought some of the Acropolis from Athens to the British Museum after seeing the ruins used as a quarry.



Big Ben under renovation

Members of the group toured London for three days, then diverged for a week and a half of independent travel. Although some of the students remained in Great Britain, most crossed the English Channel to the continent and continued their journeys.

As the time to return to the U.S. drew near, the students began to converge upon London. Some, however, found a rail strike in Belgium frustrating. One of the students, Bruce Rittenhouse, left West Berlin late Saturday night planning to arrive in London Sunday evening, in plenty of time for the Monday morning flight to Washington, D.C. He was forced, though, to divert around Belgium to Paris, delaying him for three hours. More importantly, he missed the last day train from Paris to London (via ferry crossing) by just ten minutes. This caused another five-hour delay. On top of that, the train from Paris to London was running late, causing Bruce to wonder if he would be flying back to the U.S. with rest of the group. He arrived at London's Heathrow Airport only fifteen minutes before the plane was scheduled to depart.

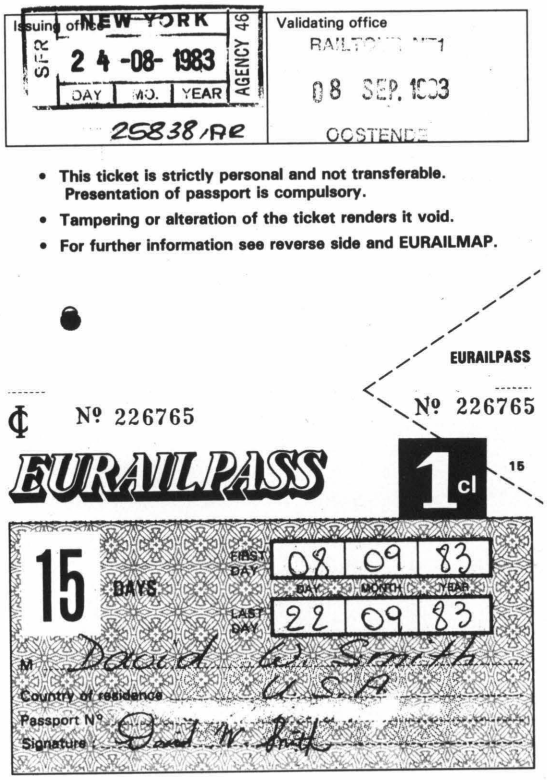
Rail strikes aside, the trip went well. The group enjoyed the opportunity to broaden their perspectives on the world around them. Each country presented different challenges—different languages, different customs, different monies and different experiences the students will remember for a long time.

## Travel Notes

*Trains:*

Eurailpasses enabled the students to take advantage of Europe's comprehensive rail system. The Eurailpass may be purchased in the United States and some other non-European countries. The Eurailpass eliminates rail ticket purchases and provides convenient unlimited rail travel during the period of validity (usually 15 or 30 days).

Traveling at night on trains saved money and freed the day for sightseeing, an advantage on a short trip. A first-class compartment normally seated six people and slept two, three or even four people spaciously. The disadvantage was that you might end up in a full compartment (if you were lucky enough to find one at all). Spaces in sleeper cars could be booked, but most people who had done so complained of frequent interruptions, such as train and customs officials asking for tickets and passports at every stop.



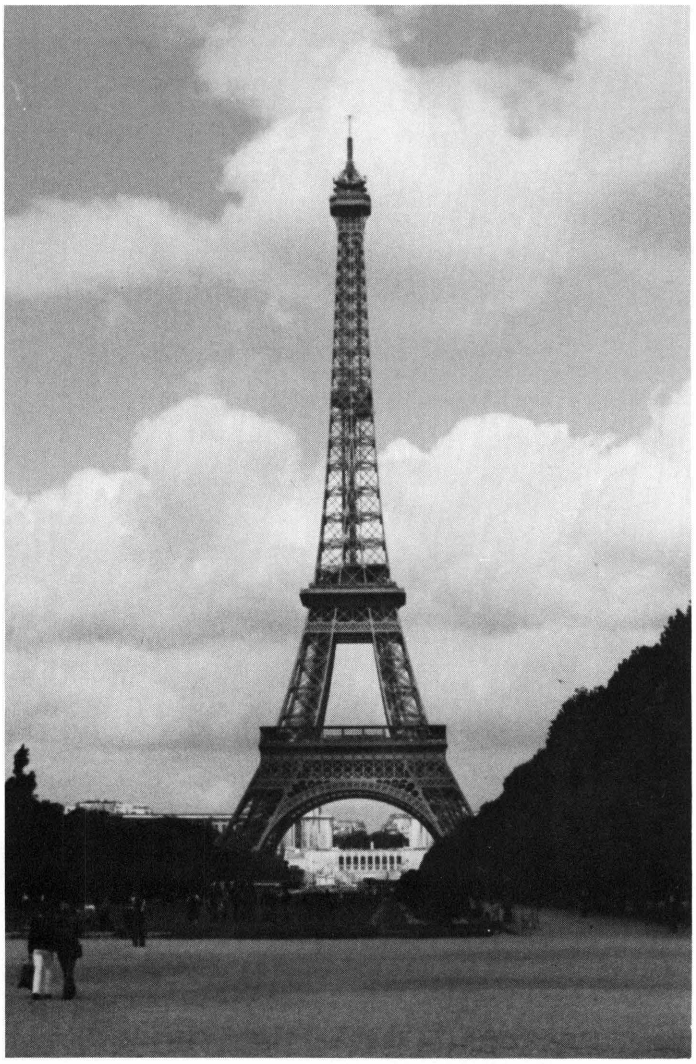

The Eurailpass

*Paris:*

One of the stops was Paris. Students proved that you could tour Paris in a day—if you didn't get killed by the traffic. The people drive in a panic; the laws of the road follow the survival of the fittest with the pedestrian having no right of way.

A view from the Eiffel Tower reveals the sprawl of Paris along the banks of the Seine. According to the students, hours could be spent admiring the Mona Lisa, Venus de Milo, Winged Victory, and the other works found at the Louvre.

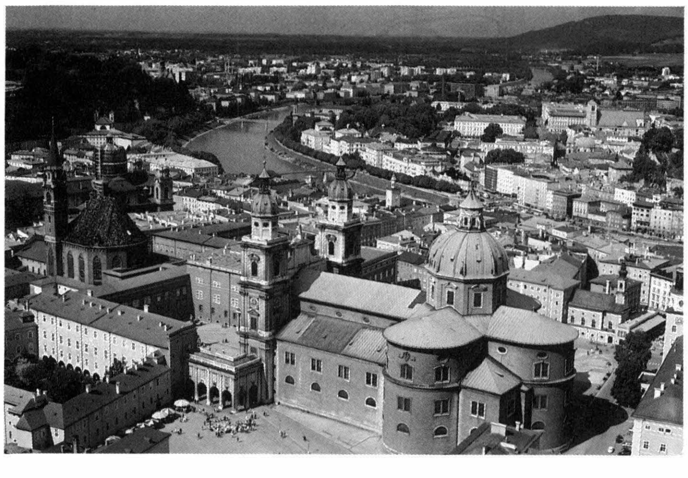
The Moulin Rouge has a fabulous floor show with dancers, laser effects, and performing dolphins. Students Jim Strawbridge and Sean Kelly got in free. They simply had to sit at the bar and buy a drink, but the twenty-one dollar gin and tonic, Jim says, was worth it.



The Eiffel Tower, Paris

*Salzburg:*

The overnight train arrived in Salzburg, Austria about 5 a.m. With the banks closed, money exchange was impossible, so the pay toilets were inaccessible. Travellers, however, could sleep on the floor of the train station and wait until things opened. Salzburg boasts four castles, Mozart's birthplace, and the first Baroque cathedral north of the Alps. Visitors are encouraged to sample the wienerschnitzel and streusel at Augustina's Beer Gardens, formerly a monastery.



Salzburg, Austria

*Culture Shock:*

Traveling to foreign countries can induce culture shock. The language difference is sometimes a problem, but trying to speak a few words such as "Hello" and "Thank you" in the native language can go a long way. Facilities in Europe differ greatly from those in the U.S. and vary widely throughout Europe. For instance, public restrooms are conveniently located throughout cities; however, finding the correct change for either the restroom attendent or pay toilets can be difficult. Finding the way to flush the toilet is no trivial task either. (Where is the chain, knob, pedal, lever, or button to tug, lift, stomp, pull, or push?). And something else that drew comment from almost everybody in the group was the variation in toilet paper, ranging from waxed paper to paper towels.

Neuschwanstein Castle near Füssen, West Germany

The crowds at Munich's Oktoberfest

*Munich:*

The train ride from Salzburg to Munich, West Germany, lasts about two hours. Munich has much to offer any world traveler. As with any large European city, Munich is replete with museums, cathedrals, and monuments. However, the areas outside of the city are not to be neglected, such as the Bavarian Alps or Neuschwanstein castle (the one after which Walt Disney modeled Cinderella's castle).

Perhaps something that everyone should visit is what is left of the Nazi concentration camp at Dachau, on the outskirts of Munich. Only a few of the buildings remain and a few others have been reconstructred. However, a walk around the compound is a moving experience.

Getting around Munich is easy, especially for Eurailpass holders. The S-Bahn, a train system which runs within the city and to outlying areas, is available to Eurailpass holders at no extra charge. The U-Bahn, a subway system operating primarily in the city, is also very convenient, but tickets must be purchased before riding. Ticket purchase for the U-Bahn and S-Bahn is based on an honor system. However, train personnel occasionally check passengers' tickets, and those without valid tickets face stiff fines.

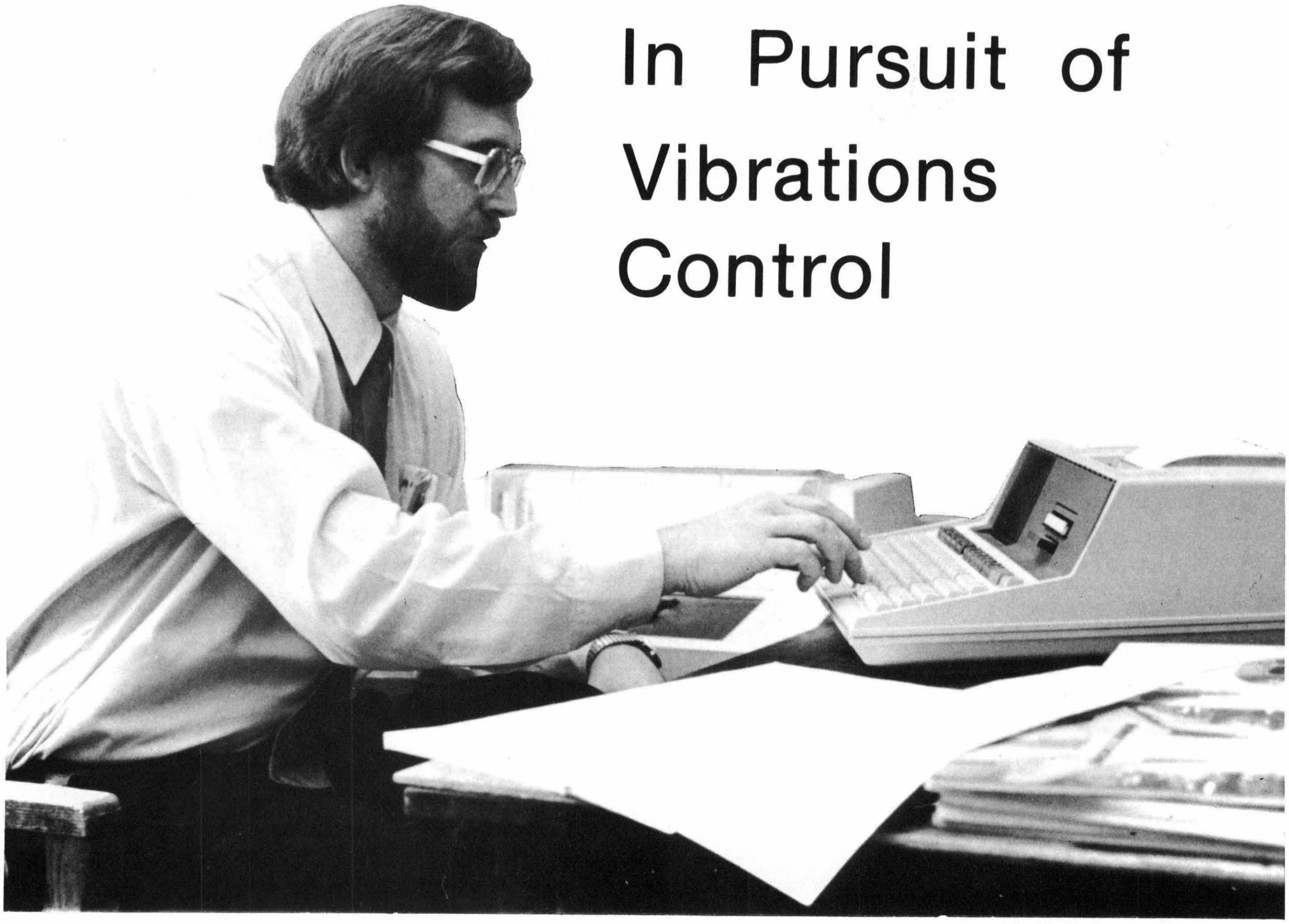
The 1983 Oktoberfest in Munich attracted millions of visitors. Over 300,000 people (including at least one Tech student) attended the first day of the two-week celebration during which people from around the world consumed hundreds of thousands of liters of beer. In addition to the beer halls and great food, a midway with rides comparable to those found at many state fairs in the U.S. entertained everyone.

*Switzerland:*

Many European travellers believe that the Swiss show the best hospitality toward tourists. A country with four official languages and dialects, Switzerland affords visitors the opportunity of assimilating wide cultural and scenic differences. Tucked away in the Alps in the German-speaking portion of Switzerland is the storybook town of Interlaken, where street cleaners even mop the telephone booths each night. Red and yellow flowers fill the window boxes, and the rivers and lakes are an unreal blue-green. In the morning the mountain peaks rise majestically above the fog.

Private railways (not included in the Eurailpass) can be taken to reach the resort areas such as Grindelwald and Lauterbrunnen. For about $50, you can purchase a round-trip ticket to Jungfraujoch, which at 11,333 feet altitude is one of the highest railway stations in Europe.

The Swiss Alps



# In Pursuit of Vibrations Control

by Mark Moran

Control theory as it existed in the early seventies intrigued Tech's Dr. Leonard Meirovitch. It intrigued him enough that he decided his talents and knowledge of engineering science should be exercised in what has become a rapidly evolving field of research. Today Dr. Meirovitch and a colleague, Dr. Leonard Anderson, are pursuing a means of preserving a structure's geometry in the presence of unpredictable forces. Applications? The United States' space program.

"Originally," explains Dr. Meirovitch, "spacecraft were very small, and could be regarded as rigid bodies; then, the problems were primarily of dynamics." In his distinctive accent, which he retains although he has resided in the United States decades now, the professor adds that, at the time, the contemporary solution to the problem consisted of passive devices, such as spin stabilization, the practice of maintaining an orientation of what is usually a small, rigid object by spinning it about some axis of symmetry. "But," he continues, "as the satellite spacecraft grew in size , and in flexibility, then it could no longer be considered rigid. And so at some point it became so large and flexible that passive means of stabilization were no longer adequate." He later adds, "When I saw how the field was evolving, then I decided that it was time for me to get into controls." He was amazed, he says, to deiscover that virtually no control theory sketched in terms of flexible structures existed when he entered the field.

Leonard Meirovitch smiles periodically as he speaks fluently. His office occupies a volume no greater, probably, than any other professor's on the second floor of Norris Hall, yet he seeams at home. Maybe it is that his subject is his home.

## A "Breakthrough"

The theory Meirovitch has developed is called Independent Modal Space Control. It is the culmination of many years work. Recently, the theory was subjected to a test at the National Aeronautics and Space Administration's Langley facility. The test, which uses a so-called free-free beam, mkeaning unconstrained at either end, has proven successful. Meirovitch calls it "a breakthrough" in the sense that actuator-modified oscillations formely unresolvable, can now, by means of the Independent Modal Space control theory, be resolved into sets of independent equations representing natural modes.

"The Langley experiment is very interesting," says Meirovitch. "It takes...sensor data, consisting of displacement measurements, and sends this data over cables to the Computing Center. There the data acts as input to a program I have developed together with a former graduate student, now a assistenat professor at Rutgers University, namely Haim Baruh. The computer program will take the sensor data and convert it into actuator forces-actuator commands-which will be sent back to the ...acuators which apply the forces. So it is very satisfying to see how the beam is being controlled, because there are many more ways to render this beam unstable than render it stable."

Leonard Anderson confesses similar satisfaction: "It's like giving birth to a new child," he said one day. "It's a very exciting moment to see your weeks of derivation and your weeks of programming all proved correct when the program works exactly as you said that it would...A very satisfying experience to see it all come together when what you had thought through, then worked on paper, then applied to the computer finally comes home and produces good results." Anderson explained earlier that his involvement with Dr. Meirovitch's vibrations control studies came about after his having attened a seminar presented by Meirovitch. He approached Meirovitch, and the two discussed research. Later, Anderson was invited to "drop by." He did, and soon Anderson assumed responsibilitiess for the "numerical aspects," the practical end, of Dr. Meirovitch's theories.

Dr. Meirovitch

### Polishing and Communicating

That "one can never be satisfied," as Meirovitch puts it, is illustrated by the ongoing nature of his work: to date, he has published eighty or more articles in various technical journals, such as that of the American Institute of Aeronautics and Astronautics, that summarize his progress to one point or another. The Meirovitch-Anderson collaboration will culminate in August when they present their results to the AIAA.

But the research will go on, and so, says Anderson, will their collaboration. "I would like to do a thorough testing," he said, "and perhaps do collaborative design work using this methodology. When you develop a control law design method specifacally for large-scale lenear systems, you would like to see it applied. You would like to collaborate on a real project in private industry, in the Air Force, or NASA, and work in some parallel fashion with them to provide technical support and opportunity to implement what you are developing in research."

And their findings, as in the past, will reach their peers through the technical journals. But what of the ordinary tailor or farmer, who, according to Meirovitch, will himself sooner or later be affected through indirectly, because what happens above his head (pun not intended) will influence not only his personal security, but his income, his health even (Meirovitch points out the medicines that such research as his will help make possible to be manufactured in space)-how will he/she learn of these and future developments?

Meirovitch relates a curious anecdote about the layperson. Meirovitch was explaining orbital mechanics to an architect. He was telling the architect how involved calculating intercept orbit is-how difficult it is to make one vehicle in orbit approach another in the same orbit.

"Why don't you just 'give it more gas'?" asked the architect.

To an engineer like Meirovitch, the response was hilarious. "To the layman," he stresses, smiling, "it's a natural question to ask. The thing is, if you give it more gas-in other words, you fire your rockets-you'll never stay in the same orbit...you achieve exactly the opposite effect."

In wrapping up my interview with Dr. Meirovitch, I discovered his concern for good communication among people his final comment:

"From the nature of your question," he told me, "it seems like you're not that familiar with the subject...Things have a way of getting distorted in translation."

But sir! I wasn't moving that fast!

# Agricultural Engineering

*Continued from page 16*

Sweet sorghum is another possible energy source of the future. In the center of the sorghum stalk is pith, a soft, spongy center high in sugar content. By distilling the pith ethyl alcohol, a highly volatile liquid can be produced. It has been estimated that a field of sorghum may contain 50 to 100 percent more energy than a similar field of corn.
sweet sorghum as a fuel source for the pst few years. Because they ahave such a long growing season, the farmers there are able to harvest the crop at a time when the mills used on their other produce are free to use.

Virginia farmers have the growing conditions necessary for the sorghum, but need equipment to separate the pith from the rest of the stalk. Dr. Dundiff is working with two of his students, Robert Brandon and Bryan Lankhorst, who are designing such a model for their senior project. Hoping to design a machine more efficient than the mills, Brandon and Lankhorst are running rests on a model Dr. Cundiff helped them put together. After examining the data they collect, the two will make decisions concerning such things as motor speed, type of knife shape, and size of chunks to be cut. The end result will be a machine capable of handling a large work volume. Brandon is really enthused about the project, enjoying the "hands on"experience of designing, machining, and assembling the parts for their test model.

Two other students, Aubrey Nuckols and Mark Dearing, are working on a digital control circuit for their senior design project. Their goal is to design a device to help collect the data needed to mathematically model the drying of peanuts. Although these projects only count for six credits, they often get very involved. Nuckols found himself taking two electrical engineering courses needed for his work. By the time their projects are completed, all of the agricultural engineering seniors will have benefitted tremendously from the experience and the responsibility to plan and perform their own research.

# The Center for Adhesion Science

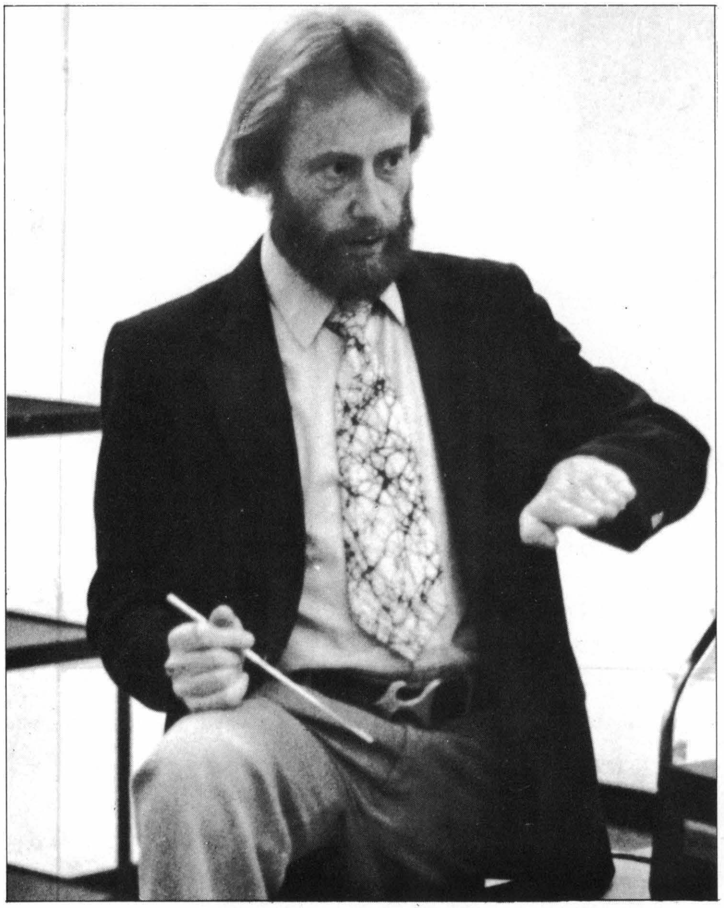
*by Janet Hein*

In 1982, four Virginia Tech faculty members from the Chemistry, Materials Engineering (MatE), and Engineering Science and Mechanics (ESM) departments founded the Center for Adhesion Science (CAS). The Office of Naval Research (ONR) provided funding. The members are Professor Halbert Brinson, ESM; Associate Professor David Dwight, MatE; and Professors Thomas Ward and James Wightman, Chemistry. These men combine specialties in order to research adhesion mechanisms by unifying the macroscopic continuum mechanics approach for developing descriptive equations and stress analysis, the microscopic view for investigating the surfaces and interfaces, and atomic-molecular level investigations to define the chemical bonding.

However, the Center for Adhesion Science provides for more than research. The CAS also provides an opportunity for both graduate and undergraduate students to take adhesion-related courses in various departments as well as to share research equipment and laboratory space. Moreover, American Chemical Society short courses on related subjects are taught by the CAS members throughout the year. Another goal of the CAS is to provide an information exchange between the researchers and the users and suppliers of adhesion technology. This is acheived by conferences and an active seminar program.

Adhesion technology is necessarily interdisciplinary. The bond between the adherend and the adhesive must be analyzed by physical and chemical investigations, with both macroscopic and microscopic methods. The strength of the bond must be analyzed both by stress analysis and by the nature of the bond. This is accomplished by the exchange of expertise between the different disciplines and by the use of a wealth of simple to very sophisticated equipment.

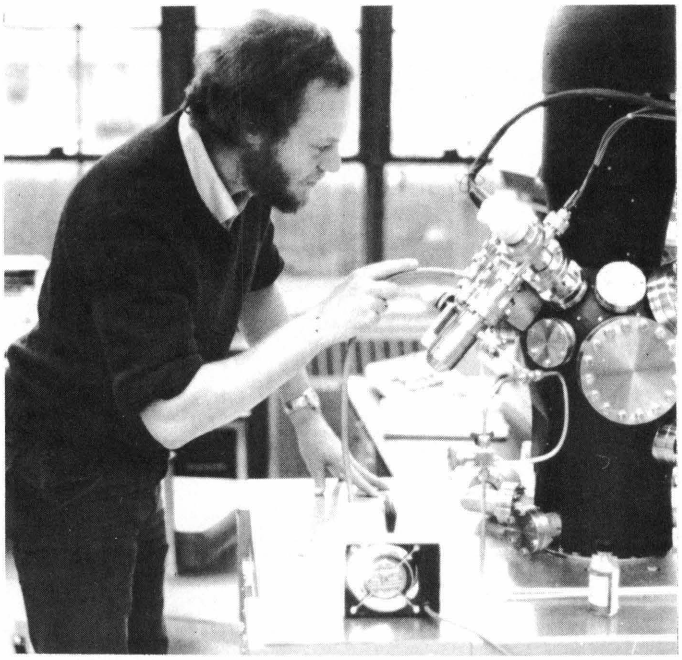
Professor Brinson, of the ESM department, investigates the stresses of the adhesive joint in order to determine its load carrying capacity. This analysis is is extremely complicated; the adhesive is polymeric, and when under stress, its properties are time dependent; i.e., the adhesive is viscoelastic. Such analyses made in the past have assumed that the properties are homogeneous, isotropic and elastic. These assumptions, however, are unfounded because of the time dependency of the properties and because of impurities added to the adhesive for various reasons. Because of possible load eccentricities, bending and peel stresses must be taken into account, as well as the normal and shear stresses. Because of these complications, calculations of the strain distribution based on basic assumptions do not agree



After a seminar, Associate Professor David Dwight, describes some fracture surfaces.

with experimental data. Therefore, much experimentation with photoelastic procedures and external extensometers is being performed. To complicate matters further, most adhesive bonds contain air bubbles and other impurities, which cause stress concentrations. Using such nondestructive test techniques as C-scan, X-radiography and neutron radiography, the quality of the bond before loading can be determined. Under long-term loading, creep ruptures occur. Professor Brinson has successfully predicted such long-term data from short-term measurements. In summary, the main thrust of Professor Brinson's research is creating workable models for the complex mechanisms of an adhesive bond under loading.

In the materials science area, the bond interface (between the adhesive and the adherend) is being closely investigated. Whether the mechanical or the chemical bonds play a more important role in the adhesion mechanism, and what roles they do play, is the major concern of Professor Dwight. The bonds are deliberately failed under various conditions, and the



failure surfaces are investigated. This kind of study is called fractography and is carried out with some highly sophisticated methods and equipment, such as X-ray photoelectron spectroscopy (XPS or ESCA) and X-ray flourescence (EDAX), used in conjunction with a scanning electron microscope (SEM). Pictures to a depth of 10 A and data about the chemical composition of the surface can be obtained by XPS.

Soon, the CAS will have the use of a scanning transmission electron microscope (STEM) for such analysis, enabling even greater resolution—to 1,5Å. The surface is prepared for an optimum mechanical bond by both chemical etching and ion beam sputtering.

The chemical nature of the adhesive bond is investigated by Professors Ward and Wightman of the Chemistry department. Different types of adhesives are being characterized. For example, a series of block copolymers of the styrene-styrene type has been investigated as one possiblity. The characterizations include molecular weight distribution, network structure, and thermodynamic and kinetic qualities. Also being characterized is the surface oxide layer on metal adherands, such as those on aluminum and titanium 6-4. A recent interest has been in the relation of surface pH to observed interfacial qualities.

The Center for Adhesion Science, although primarily funded by the ONR, receives monies from other government agencies and private industrial users of adhesion technology. The field is still in its infancy, and much new supporting technology is being used, as the STEM. Adhesives offer many advantages over other presently used methods for attachment in everything from ships to planes to household items. The CAS is making much progress toward making adhesion artistry into a science.

# LANDSAT

*by Lisa Shaver*

Many students may be surprised to learn of the extensive amount of Engineering research being conducted at Virginia Tech. In the Civil Engineering Department alone there are more research projects than faculty members, indicating the degree of faculty involvement in funded research projects. There are many interesting studies being conducted within the Hydrosystems and Transportation Divisions of the Civil Engineering Department, a few of which will highlighted.

The faculty in the Hydrosystems Division carries funded research projects in the areas of hydrology, hydraulics and water resources engineering. Dr. Kuo is presently involved in a water quality monitoring project funded by NASA in which he is investigating the turbidity of the John H. Kerr reservoir by means of remote sensing techniques. The field work portion of Dr. Kuo's research involves collecting water samples from the reservoir at the same time that data is recorded on board an earth satellite, referred to as a landsat, passing over the area. On board the landsat is a sensor which picks up signals, known as upwelling radiance, which are reflected off the surface of the water. The signals will differ depending on the concentrations of suspended sediments present in the water.

Data from the in-situ samplings and the upwelling radiance recorded by the scanner on the landsat are then correlated in order to map equal concentration lines for the surface suspended sediments. Statistical methods are then used to quantify the data so that in the future, prediction about the concentrations of suspended sediments can be made using those previously develped for a particular area. The development of this remote sensing technique greatly reduces the manpower and equipment necessary for mapping and developing models of water surface concentrations of sediments.

The data that can be collected by use of this remote sensing technique has many applications. For example, the technique has been used in the mapping of ocean sludge concentrations as a result of the dumping of New York City sludge into the New York bay. Mapping done over a period of weeks gives information on the concentrations and dispersal time of the sludge. The results aid in developing the most environmentally desirable disposal scheme for the sludge.

Another use of remote sensing techniques has been in the monitoring of heated water discharge at Surry Nuclear Power Plant on the James River. The mixing and diffusion of the thermal discharge has been mapped using isothermal lines. The results from these studies are used to develop standards for regulating heated discharges into the river in order to protect the river's environmental balance. In another area concerning water resources, Dr. Kuo is working with Dr. Loganathan of the Transporation Division on a project concerning instream low flows. By first determining the recurrency intervals for droughts, for example, the water available during a dry season can be determined. Considering the instream requirement of water for plants and wildlife,the water available for purposes such as farming can be determined.

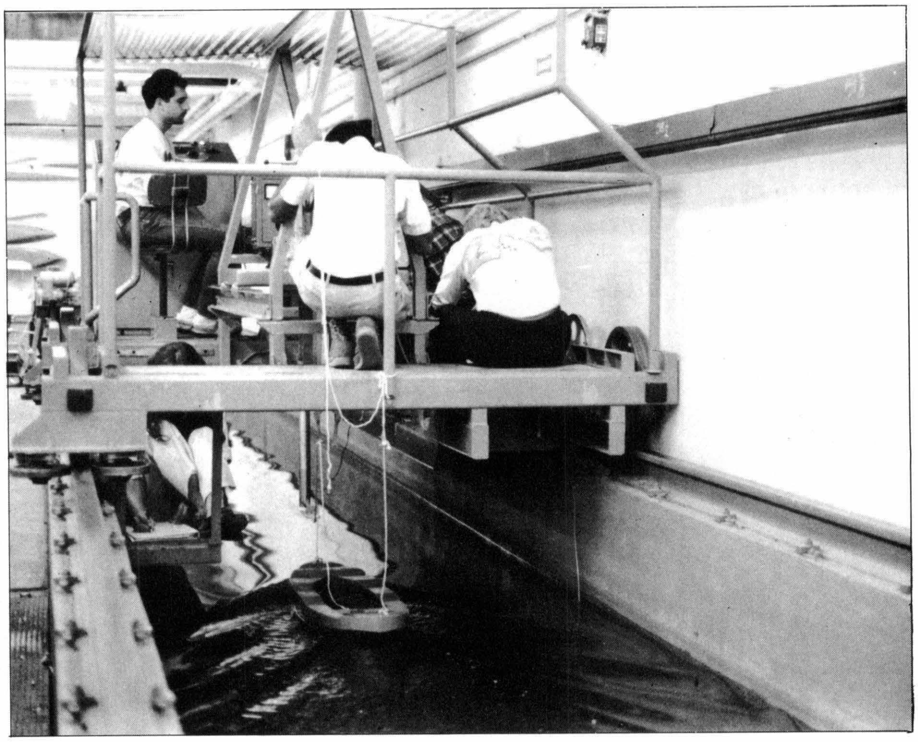
By helping state and federal agencies develop a simple method to predict stream flow, a suitable water management program can be developed, taking into consideration particular socioeconomic, institutional and water resources conditions.

Within the Transportation Engineering Division, Dr. Hobeika and Dr. Radwan are in the initial stages of developing evacuation plans to deduce highway evacuation times under natural disasters. In an attempt to reduce traffic congestion and evacuation time, the plan will involve the identification of the fastest yet safest

In one case study, a hurricane evacution plan for the city of Virginia Beach will be developed by Dr. Hobeika and Dr. Radwan. The plan will not involve the identification of an appropriate road network, but will also evaluate the workability of the present shelters. These shelters are located in public buildings such as schools, churches and libraries. In addition, existing resources such as public transportation vehicles and school buses will be evaluated to determine their usefulness in an evacuation plan.

In a different aspect of resource management, Dr. Tran and Dr. Loganathan are developing a system dynamics computer model that has the capability of predicting and analyzing long and short term impacts of land use policies on water quantity and quality. Based upon the natural resources currently available withing the state of Virginia, the model will help to evaluate the best land use management policies for the future protection of Virginia's water resources.

# There is an Ocean in AOE



AOE students test a ship model in the towing tank located in Norris Hall.

*by Ann Raridon*

Most people know that Virginia Tech has an excellent aerospace engineering program, but how many know that ocean engineering is part of the same department? A company representative spoke with a group of enthusiastic ocean engineering students at the Student Engineers' Council wine and cheese party. Upon hearing of their interest, he remarked, "So that's what the 'O' stands for!"

There are several reasons for the program's lack of recognition. First is the relative newness of the program—the department has been aerospace *and* ocean engineering for only about six years. Another reason is the majority of the students and faculty in AOE are primarily interested in aerospace, and consequently few people hear about the ocean aspects.

Nevertheless, all AOE students receive the same degree and the only difference between the curricula is the choice of technical electives. Many people are confused by the idea of aerospace and ocean together, but both disciplines involve the motion of a vehcile in a fliud. The principals are basically the same whether the fluid is air or water.

Although students interested in ocean engineering are in the minority, Virginia Tech does have one of the few student sections of the Society of Naval Architects and Marine Engineers, an ocean-oriented professional society. Equipment including a 98-foot towing tank and a hydrofoil testing facility is avialable and there is even ocean-related research being done by some of Tech's professors.

Dr. Wayne Neu, an OE professor, is working on a project using mathematics and computer methods to make predictions about wave generation. While working at Naval Sea Systems Command, Neu saw a copy of a special ocean wave model published by the David W. Taylor Naval Ship Research and Development Center. Feeling that the model is oversimplified, Neu has been working on a plan to refine it.

The current model takes initial wave conditions and wind data for various points in the ocena and uses them to calculate the growth of the wave energy spectrum for each point. The growth is then projected over direction using an assumed spreading function which is highly idealized. In calculating the wave growth, the model takes into account the wind direction but not the full directional properties of the existing wave environment. Neu would like to restructure the model to allow the direction of the wave growth to depend on the existing directionality of the waves.

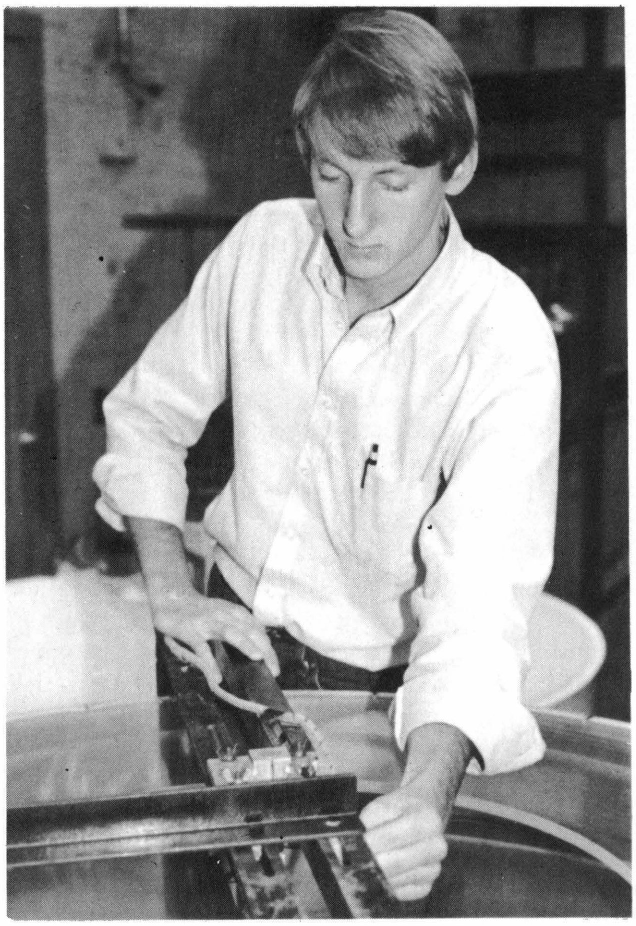
When the revised model is completed, it will predict more accurately the types of waves that can be expected in different areas of the ocean. Such information is important for both military and civilian use. Neu is excited about working on the project and will try to continue the work, even if he does not receive the funding which he has requested.

Dr. Karl Sundkvist, one of Neu's colleagues, is also interested in research. He has worked with Dr. Allen Magnuson, a former Virginia Tech OE professor, on a method for acoustic surveying of manganese nodules. These nodules were formed over millions of years by the accumulationof minerals around an object, such as a grain of sand or a shark's tooth. The nodules ususally contain several valuable and strategic minerals, such as nickel, cobalt, and copper. Valuable nodules are often found in water at depths of three or more miles. Traditional prospecting techniques require the cameras, sensors, and other necessary instruments to be lowered to the botton with cables, and the depths make this process slow and costly.

Accoustic sensing would reduce prospecting time and costs. The technique developed by Magnuson and Sundkvist involves sending down acoustic signals and analyzing the response. The nature of the bottom can be determined from the return pulses, since the signals are reflected differenly by areas with and without nodules. Magnuson and Sundkvist conducted analytical studies and laboratory tests to find correlation between the acoustic return and the nodule size and distribution.

In September of 1982, Sundkvist had the opportunity to test the acoustic system on a U.S. Geological Survey cruise on the Blake Plateau off the southeastern coast of the United States. The primary purpose of the cruise was to survey some hard mineral deposits within the U.S. exclusive economic zone.

In addition to the acoustic system, cameras and coring and dredging instruments were also used. The combination of the surveying techniques enabled Sundkvist to correlate the acoustic response with actual photographs and physical samples. Besides nodule-type deposits, sheet- or pavement-type deposits were also encountered, which offered an extension of the acoustic detection problem. Sundkvist enjoyed the cruise because he had the opportunity to work on all aspects of the prospecting process, from sensing and collecting the nodules, to correlating in situ response with theory. He appreciated the challenge of trying to verify his analytical predictions.



Tom Pelczynski, a senior in AOE, readies the hydrofoil testing facility for an ocean engineering lab. Ocean Engineering Models and Methods and Ocean Engineering Lab are required for all AOE students.

Unfortunately, interest in the commercial mining of manganese nodules has waned due to low mineral prices and political problems involving the Law of the Sea Treaty. However, the government is encouraging mining development for strategic reasons. For instance, cobalt is necessary for the production of jet engines, and although it can be obtained from manganese nodules, most of the nation's supply now comes from politically unstable areas. It is hoped that both commercial and governmental interest will increase in the future.

Dr. Neu and Dr. Sundkvist enjoy conducting research, in addition to teaching, and both are helping to make Virginia Tech known in the ocean field. If research like theirs continues to be done by students and faculty here, perhaps ocean engineering at Virginia Tech will someday be more than just a mysterious 'O'.

# How to Build a Better Bridge

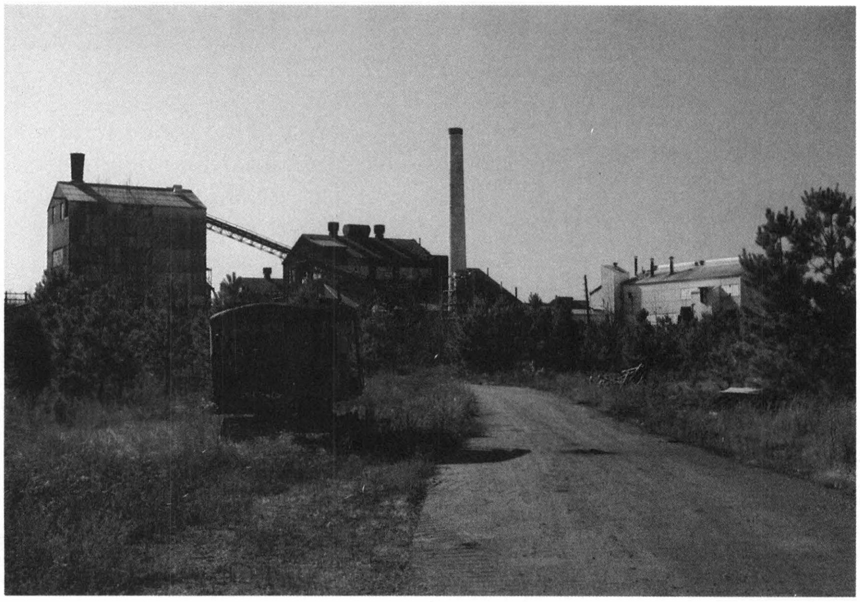
*by Michael West*

Research in Civil Engineering? On what? How to build a better sandbox? How to construct a lasting bridge? I mean how much can you do with dirt and concrete, they're almost the same thing anyway, right? I guess it would help if we knew the type of things that civil engineers do. The Civil Engineering Department at Virginia Tech is involved in numerous activities and has been quite successful. The department has received eighteen medals and awards on both the national and international levels for outstanding research and publications. The department is involved in projects of many different scopes and sizes. Current research encompasses individuals working on purely theoretical or mathematical concepts to larger group projects involving people from different divisions within the department and University.

Some members of the department are working on projects involving hazardous waste. One project sponsored by the ARCO Chemical Company concentrates on studying the biodegration of alcohol contained in gasoline in the groundwater systems. This study is of interest because when shipping and storing gasoline, there is always the chance of leaks and spills that will allow gasoline to escape into the groundwater system. In this case methanol separates from the gasoline in the presence of water and is no longer detectable in the water. Methanol is of concern because evidence indicates that it may form formaldehyde, a known carcinogen, in the body. The study will provide information to ARCO that can be used to predict the fate of contaminants in subsurface systems.

Another project involves an evaluation of the degree of contamination caused by acidic mineral deposits at a closed American Cyanamid plant in Nelson County, Virginia. The site was a titanium processing plant that was closed over ten years ago. The plant was used for extracting titanium dioxide from titanium ore.

Titanium dioxide is used as the white pigmentation in paint. In order to extract the titanium, the ore was acidified causing the metals to go into solution. The two common metals in the ore are iron and titanium. In the process the iron is precipitated out in the form of ferrous sulfate. When ferrous sulfate comes into contact with water, the reaction yields sulfuric acid which can run off into local streams. The ferrous sulfate was stored in the open and during heavy rains, ran into the Piney River, causing massive fish kills. To eliminate river contamination years ago the ferrous sulfate was put into a burial pit. Because of improper management, the pit has caved in and cracked, allowing water to reach the ferrous sulfate and continuously contaminate both the groundwater and surface streams. As a result the pH of the groundwater and some of the soil dropped below three causing damage to surrounding vegetation.


American Cyanamid Plant, Nelson County, Virginia.

The site description is enough to make you want to stay far away from Nelson County. I quote, "a substance of grayish-white material with streaks of purple that sits ten feet deep in some parts," "the site is devoid of vegetation," "flexes somewhat like rubber when walked upon," and if that's not enough, when a chunk of it was dropped from a front-end loader it "just sat there and quivered." Not one of your more common soil types.

Development of a new testing instrument is yet another area of research. The device is a miniature cone penerometer that is used for collecting information on soil properties. The scope of the project is to develop a post-earthquake soil testing kit small enough to fit into two suitcases. The kit will be used by investigative engineers who need to have the capability to travel to the site of a recent earthquake anywhere in the world. For the data they collect to be reliable it must be obtained before the site conditions are altered. Usually at a site of a major earthquake there is too much distress for the local authorities to help them. Without the help of local authorities, the investigative engineers

Cofferdam network used to seal off construction area for Lock and Dam No. 26 on the Mississippi River.

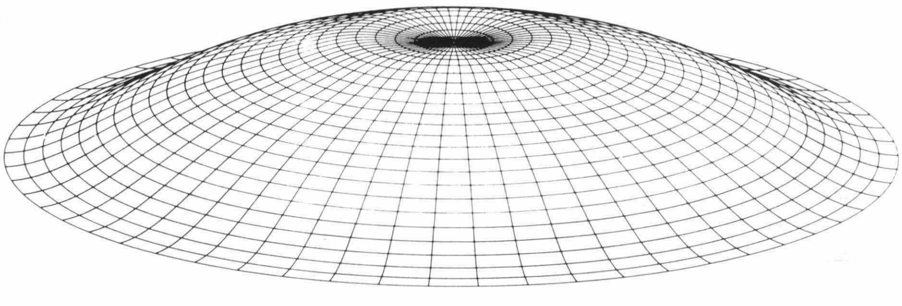
are usually unable to get the equipment and manpower to gather information on the soil. Use of this kit will allow engineers to retrieve reliable data so that they will be in a better position to understand what happened to the soil during the earthquake.

In the news lately, there has been talk about the nation's infrastructure--roads, bridges, canals, and the other systems that make up our public sector. The biggest problem with the infrastructure is that it is in need of repair. Some projects have been undertaken to repair parts of the system, one of which is the reconstruction of Lock and Dam No. 26 on the Mississippi River. The construction area which extends into the river is sealed off by a cofferdam network. The cofferdam is built and then the construction site is pumped free of water. The Army Corps of Engineers has installed instrumentation into the cofferdam so that the forces involved can be measured and a new method of construction developed. The College is evaluating this data for the Corps. The design method that is now being used was developed in the 50's and is thought to be overly conservative. If a new design is developed using improved methods, money can be saved in construction. The structures geotechnical groups at Tech are working on modeling the forces on the interlocking sheet pilings that are used to construct the cofferdams. At this time, a two-dimensional soil structure interaction model program has been developed and plans for the immediate future include a complete three-dimensional model.

Research is also being conducted on topics that have less application in the immediate future but help increase our knowledge and understanding of an area. One such project being conducted by the structures group involves studying the most efficient design/shape of a shallow dome. The study focuses on a nearly pure mathematical optimization of geometric configuration for stability of different shape thin-shell structures. Areas of possible application include the bottoms of thin-walled pressure vessels, beer cans, or the air-supported roofs over football stadiums.

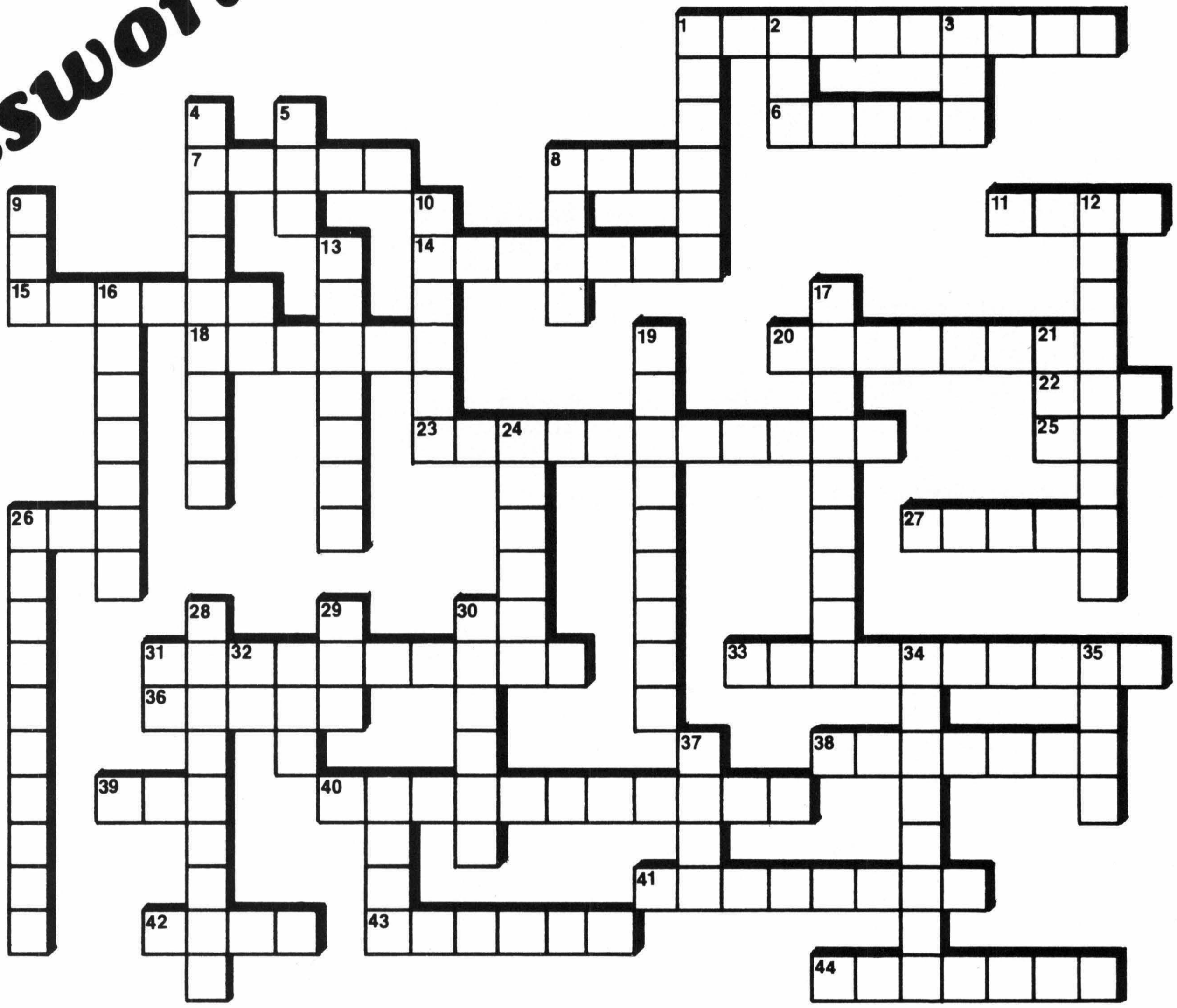
There is one project that has a huge magnitude, a model study on the effects of water in society. One example of things that are being considered is a factory using river water that must install expensive pollution control equipment to maintain the water quality. This action will result in safer water; however, there will also be a loss of capital that could be used to bring more jobs into the area. Water is in every phase of our lives. How we manage it will have a direct impact on our future. A program is being developed to include the many variables entailed by the scope of this project and give a model that will help us manage our water resources.

By now you should have figured out that civil engineers just don't build bridges. The field is very diverse and interesting for those of us who enjoyed playing in the sandbox and building with blocks as kids.



One of the Plots for the optimum design for a shallow Dome structure.

# Crossword Puzzle



**ACROSS**

1. School newspaper
6. Edge
7. Popular Fri. afternoon activity
8. Finished
11. Passing fancy
14. Computer center (Burruss)
15. See 19 down
18. See 17 down
20. Force per unit area
22. Plural of "is"
23. Temperature measuring device
25. Forgotten pass time
26. Antonym of good
27. VPI bird
30. Not yes, but
31. Test
33. Hand held computing device
36. See 19 across
38. See 14 across
39. Student instructor
40. Measurement of head effects
41. Engineering straight edge
42. See 7 across
43. Capacity to do work
44. See 26 down

**DOWN**

1. Uniformed students
2. Research room
3. Fills a pen
4. Standard lab animal
5. Engineering society
8. On-campus housing
9. Charged atom
10. ___ minded professor
12. Senior activity
13. The study of motion
16. See 14 across
17. Famous English researcher
19. Number of atoms in a mole
21. Freshman cadet
24. VIP New Jersey researcher
26. ___ Transit
28. Loss of electrons
29. Female married title
30. Created laws of motion
31. Alien visitor
32. Antonym of AM
34. Rainy day protection
35. Pig sound
37. Wish upon a

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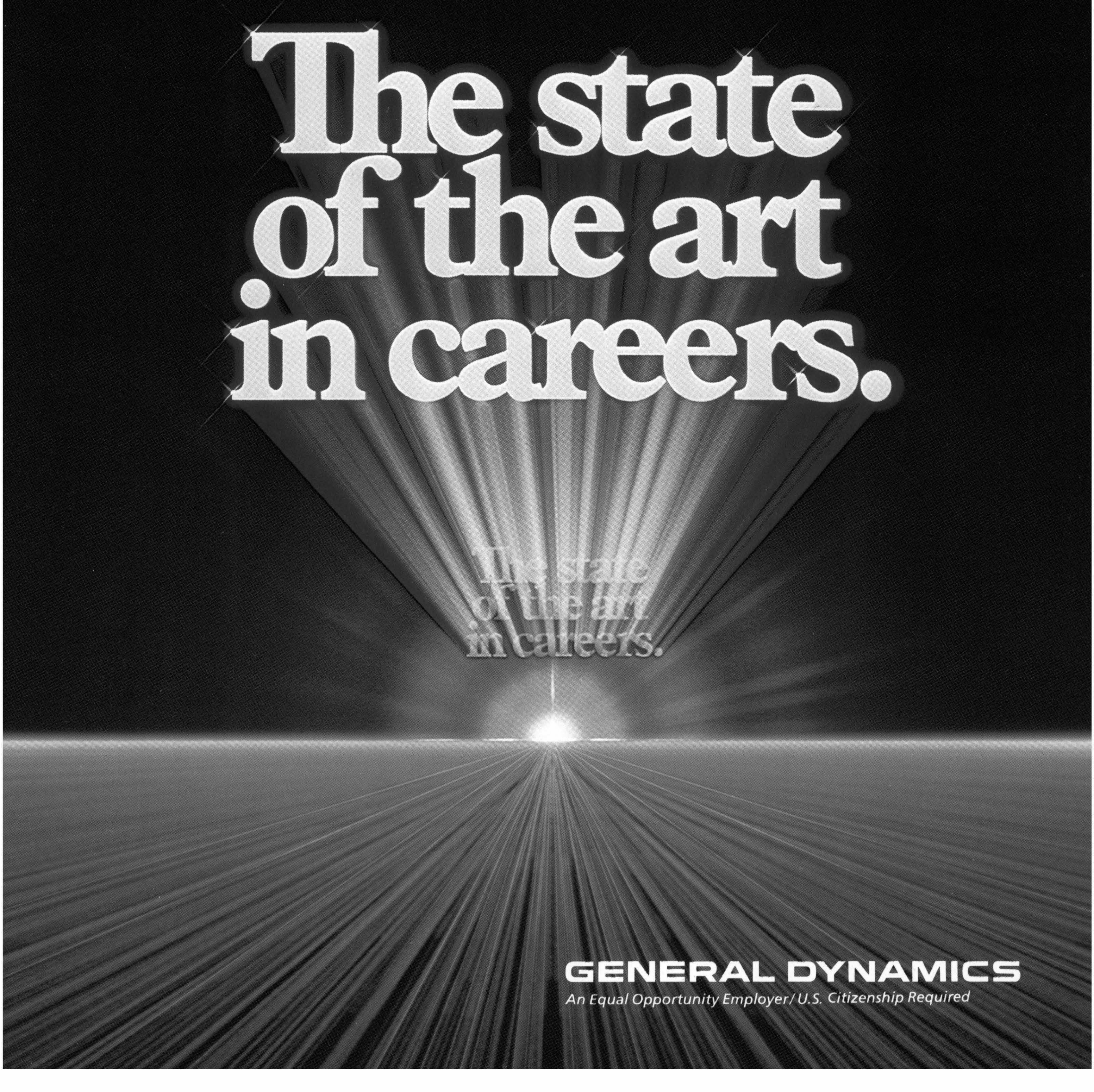
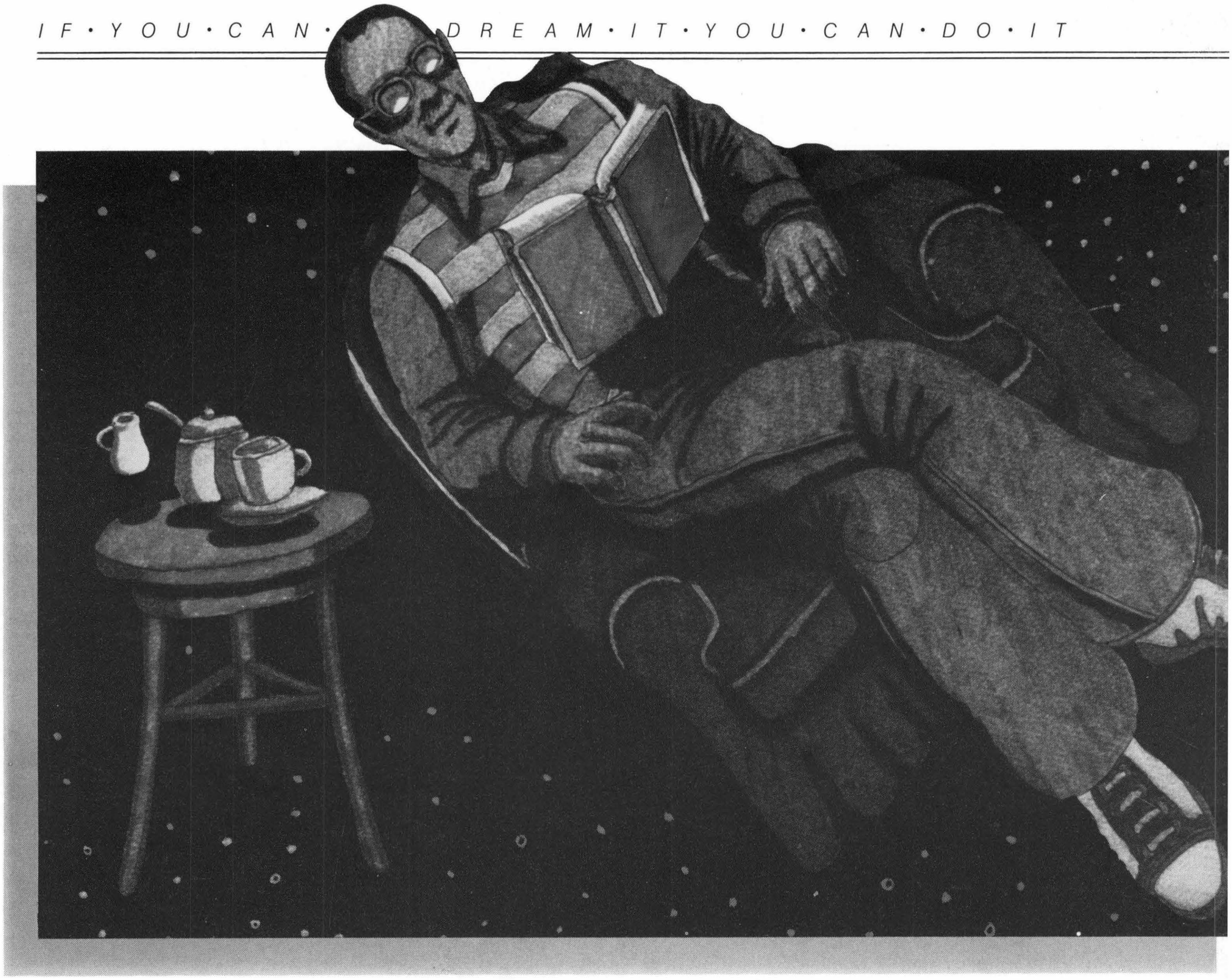


IF · YOU · CAN · DREAM · IT · YOU · CAN · DO · IT



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