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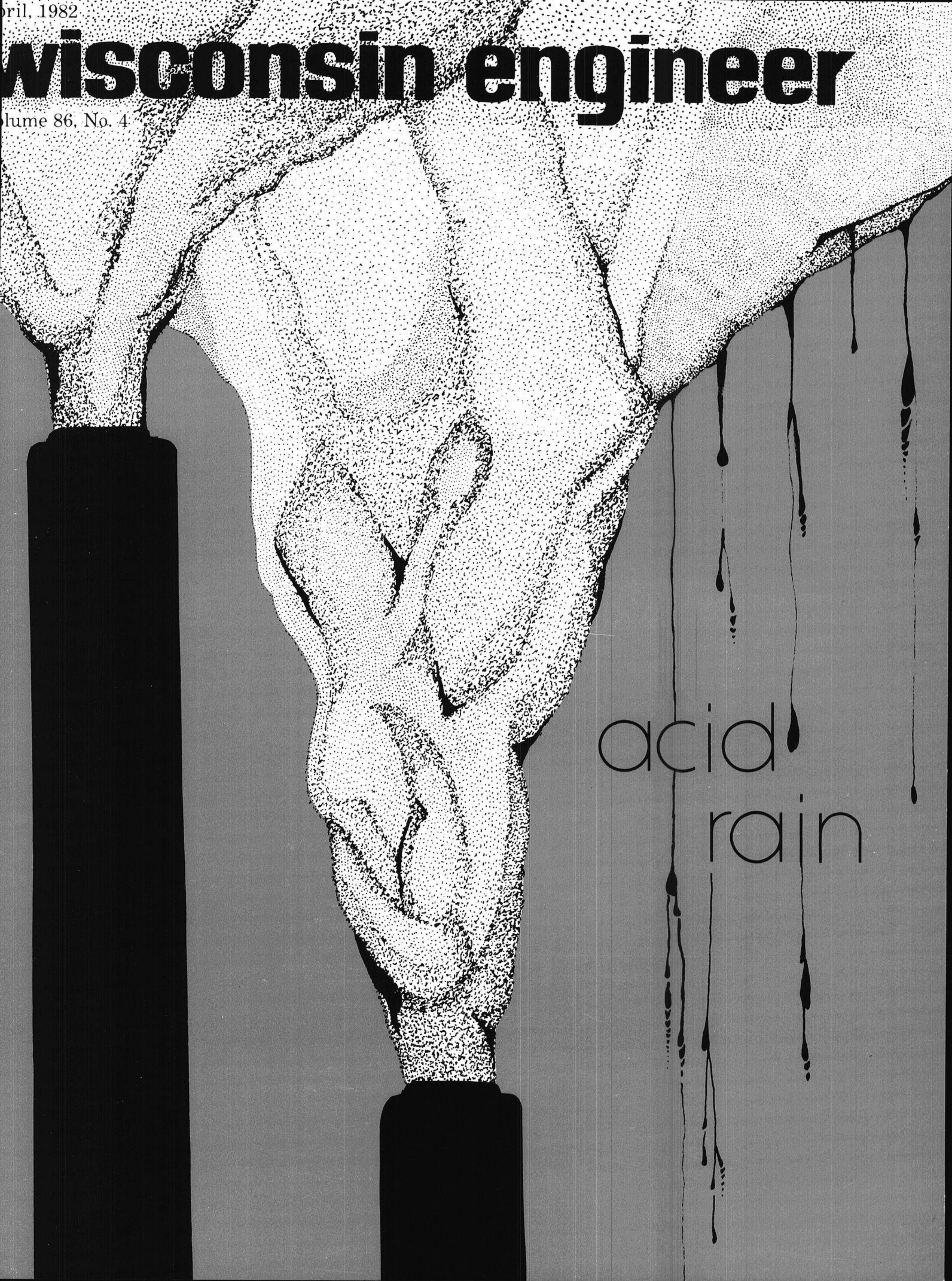

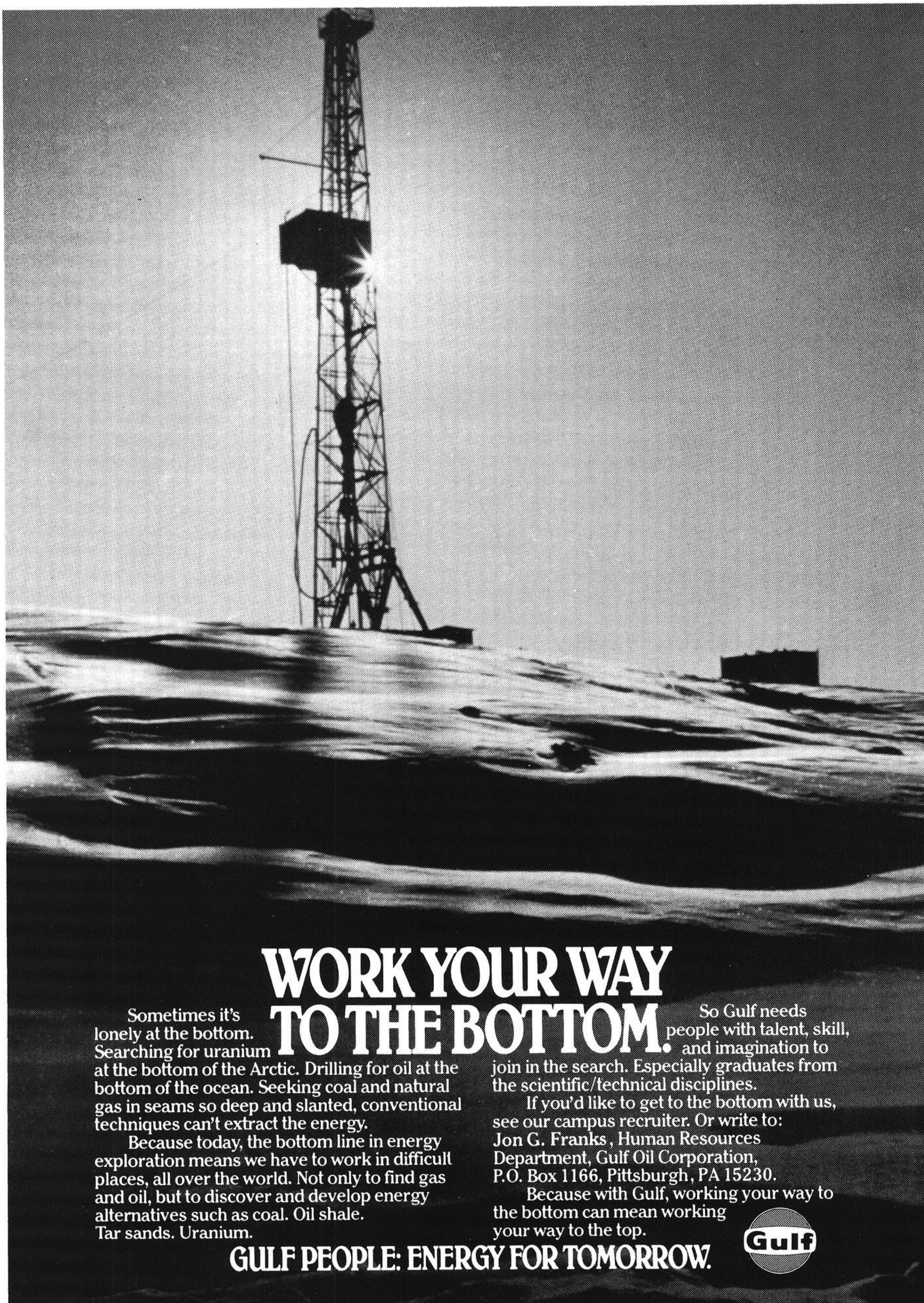

Uranium mining, Rabbit Lake, Canada

An Equal Opportunity Employer

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wisconsin engineer

PUBLISHED BY THE ENGINEERING STUDENTS OF THE UNIVERSITY OF WISCONSIN-MADISON, APRIL, 1982

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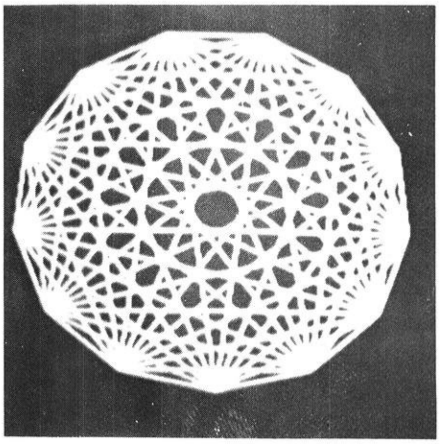

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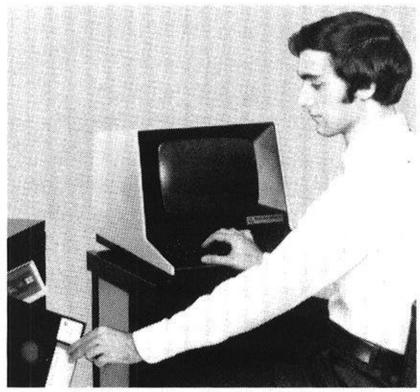

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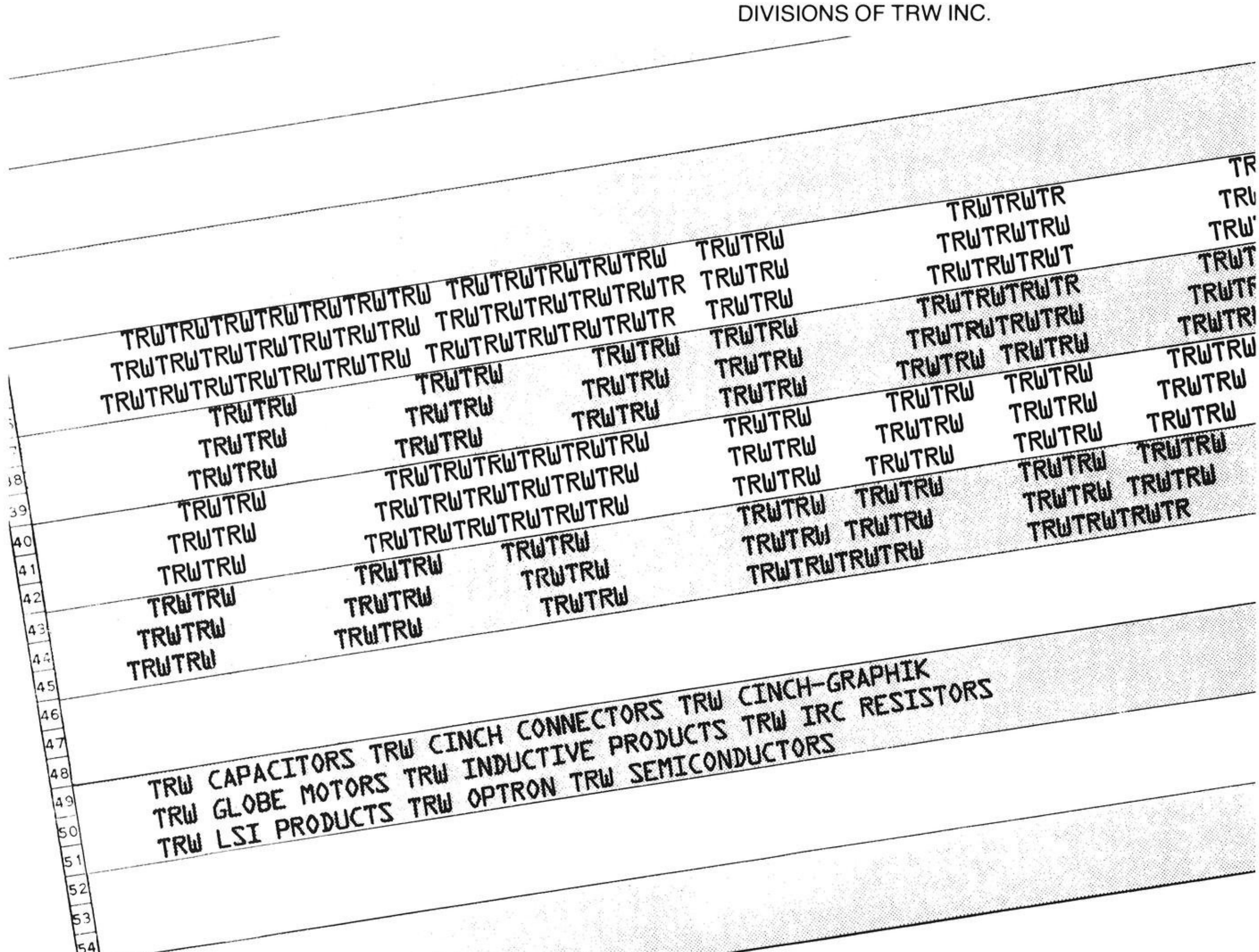


OUTLOOK

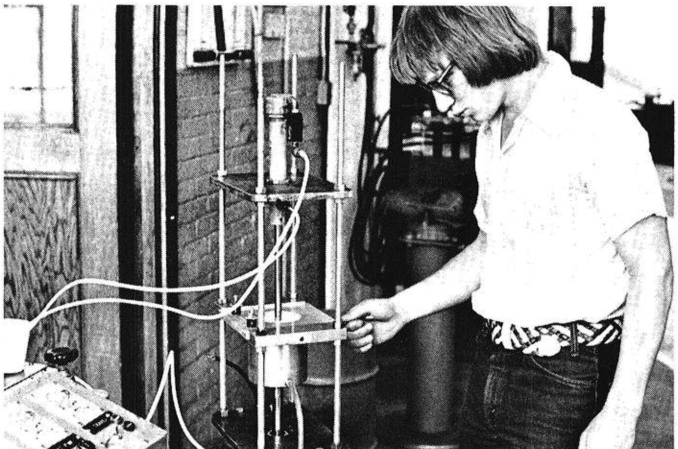
An important part of a student's academic experience involves the development of an individual capability to conceive, plan, manage, and carry to completion, a successful engineering project. Another important perspective which students should strive to develop is that of working in a team effort directed at achieving a broad group objective. Our engineering students have an exceptional opportunity to do this through participation in the 1983 Engineering Expo.

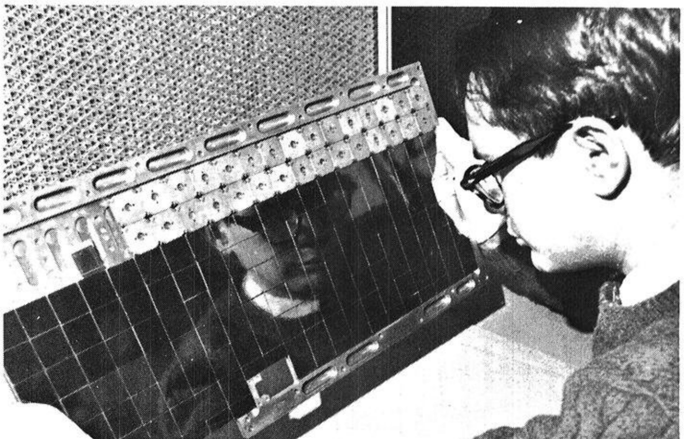
In observing over 25 years of Engineering Expos, and speaking from my personal experience as Chairman of the 1956 Expo, I cannot think of any single student activity which can lead to more personal satisfaction from both the group and individual point of view. One can serve as a member of the many organizing and operating committees of Expo. Students have the challenge of working together to develop a theme, plan exhibits, market exhibit space, and organize for an exciting period involving thousands of people. As an individual or student group exhibitor, participants build devices, and, in many cases, experience the thrill and personal satisfaction of being judged exceptional.

I urge all of the student body to take advantage of this opportunity, plan early, and volunteer for the many challenging tasks which must be integrated into one outstanding demonstration of science and technology in the spring of 1983.

John G. Bollinger
Dean
College of Engineering

3-8-82

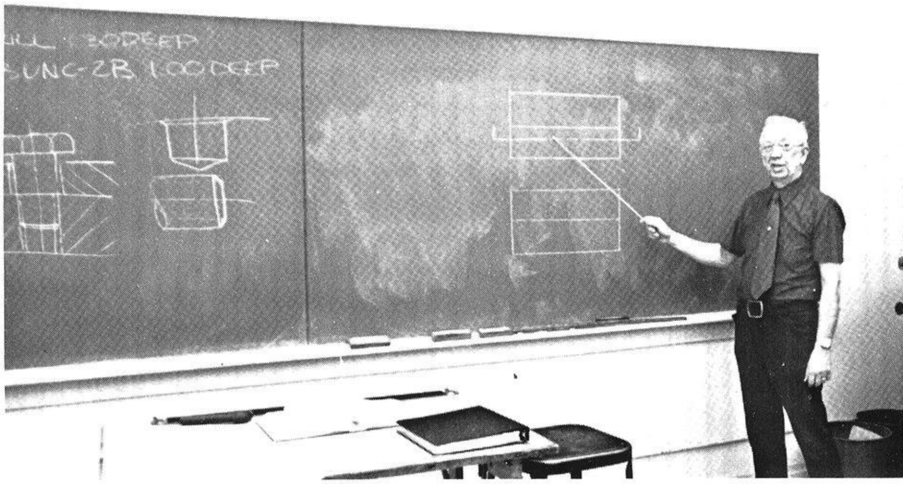




A Farewell to Professor Howard Schwebke

by David Barnas

This spring, Professor Howard Schwebke will retire after a distinguished career of teaching engineering graphics in the Wisconsin System. Howard has been the magazine's advisor for 21 years and has worked closely with our business manager, David Barnas. David thanks Mrs. Phyllis Schwebke for her assistance in writing this article.


RMJ Photo

His active involvement within the University includes this architectural graphics course.

Professor Howard Schwebke does not search for the fountain of youth because he never left it in the first place. With enthusiasm common to undergraduates, Howard is now completing his last semester as Chairman of the General Engineering Department, Executive Secretary of the Engineering College Magazine Association (ECMA), and faculty advisor to the *Wisconsin Engineer*. Throughout his career, Howard has devoted himself to the engineering education in Wisconsin, and also served our nation's military in many distinguished capacities.

Howard received his Bachelor's and Master's degrees at UW-Stout. He served as Editor and Business Manager of *The Stoutonia*, the college's weekly newspaper. Following his academic education, Howard enrolled in the Officer Candidate School at Northwestern University and enlisted in Recognition Training at Ohio State University. During World War II, he served as a Recognition and Navigation Officer on board a repair ship in the Pacific.

After the war, Howard returned to academia as a graphics instructor at UW-Milwaukee. He was later transferred to Green Bay where he taught graphics for UW-Extension schools. During the Korean Conflict, the call of duty brought Howard back to the service. He received a commission as a Blue and Gold Officer and recruited for the nation's military academies.

In 1956, Howard came to Madison to become the first Department Chairman for General Engineering. The new department had been established to instruct graphics and technical writing as well as to offer counselling for students.

Even as Department Chairman, Howard taught graphics and always kept his door open for consultation with both students and staff. His full schedule often mandated evening and weekend work, which was rewarded by the genuine respect and affection held by his students and colleagues.

The General Engineering depart-


RMJ Photo

Howard cultivates enthusiasm through personal involvement with his students.

ment has continually adapted to the changing needs of engineering students. In the dawn of computer-aided design, the department has kept pace with industry by offering computer graphics courses in its new terminal room. The "computerization" of his department demanded a great deal of Howard, who was responsible for its transition to the future.

The nobility of a college professor is reflected by his interest in his students outside of the classroom. Howard's commitment to the *Wisconsin Engineer* magazine has benefitted hundreds of students. The *Wisconsin Engineer* has seen undergraduate staffs come and go, but through the years the magazine could always depend on its faculty advisor.

His devotion to engineering student journalism has earned appreciation nation-wide. Howard has served as the Executive Secretary of ECMA for the past nine years. The ECMA is composed of 32 student engineering publications from colleges all across the country. Each year the ECMA holds a national convention at which the student staffs can meet to present and exchange their ideas. Howard has been a communication liaison for ECMA and is actively involved in organizing the annual convention. After seeing to its preparation, Howard becomes the "motivating force" at the convention itself.

Professor Schwebke has demonstrated excellence not only in his career but in his community service as well. He served on the PTA, Boy Scout and Sea Scout advisory boards. Howard has served as Sunday School teacher at Trinity Lutheran and as Superintendent at Lake Edge Lutheran. In his community, Monona Grove, he has served for 25 years on the Planning Commission and was recently honored by having a Distinguished Service Award bestowed upon him.

RMJ Photo

For the character and quality he has inspired in our magazine, we thank Professor Schwebke for 21 years of guidence.

A military wedding complete with crossed sabres was in order for Howard 38 years ago. His wife, Phyllis, is currently Chairman of Home Economics at MATC. Both their sons, John and James, earned the Eagle Rank in the Boy Scouts and Pro Deo Awards. John, a graduate of Valparaiso College, is married and Vice-President of Marketing for the Farm Bureau. James is also married and a graduate of UW-Oshkosh. He is a marketing representative in Wisconsin for an insurance investor.

RMJ Photo

As representative to ECMA, Prof. Schwebke lays the groundwork for smooth communication within the group.

Career and family have not prevented Howard from enjoying his hobbies of photography, cooking on the Weber Grill, and traveling. His travelog includes accounts of Hawaii, the Caribbean, Europe, Scandinavia, Australia and the Seven Seas. Howard also hits the road three times a week as a vigorous jogger.

This summer the Schwebkes will move to Arizona. A plan map of their homestead is already hanging from an office wall. After this map and his older desk "treasures" are packed, Howard's office will become only a room. The stacks of ECMA letters will have to be piled somewhere else; the *Wisconsin Engineer* staff will need to find another place to await the arrival of the latest printed magazines. Though the movers may leave it ajar, the office door couldn't assume the openness that Howard's character effected.

However, Howard will never leave Madison: every time a student completes a course or the magazine wins an award, the occasion will ring of Howard's contributions to our college. We thank Prof. Schwebke for his devotion and wish him continued success and happiness in his retirement. □

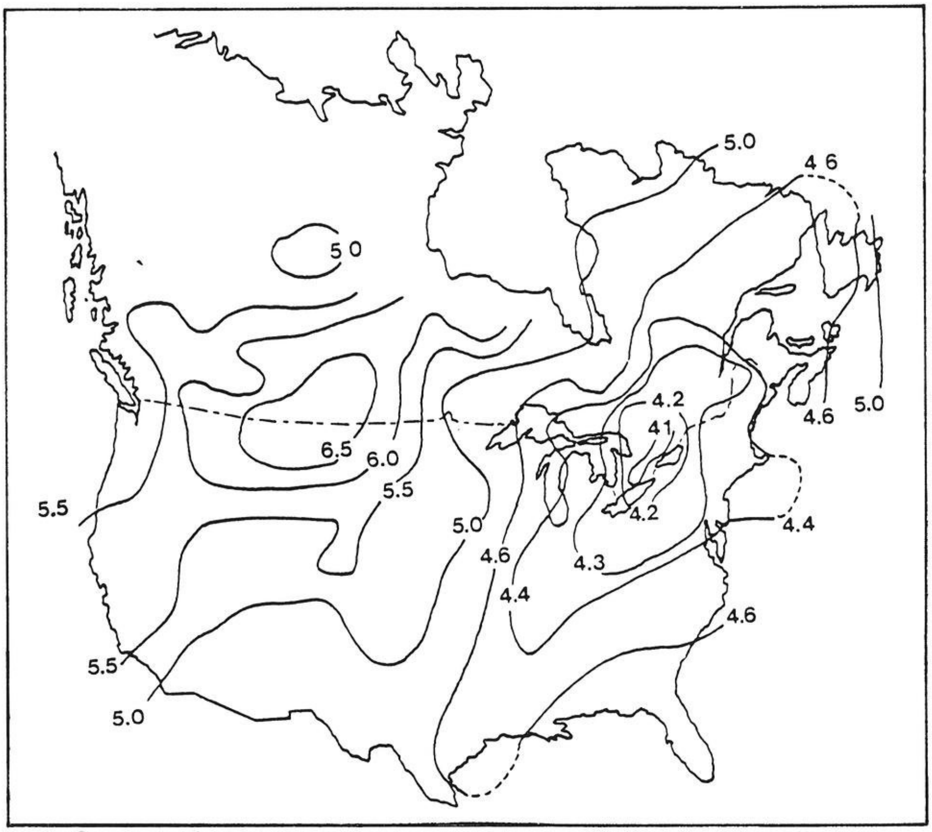
Clearing Up Acid Rain

by Eric Loucks and Dr. O. L. Loucks

Eric Loucks, a regular W.E. contributor this year teamed up with his father to put together this piece on the most recent information concerning the fate of acid rain in the environment. Dr. Loucks is the science director of The Institute of Ecology in Indianapolis. For more than ten years he has worked on research approaches to multidisciplinary environmental problems. This involves the synthesis of principles from many branches of science into competent and complete environmental impact evaluations. Eric compiled this article from an assortment of his father's recent publications and working notes. The pair is planning a joint investigation of the influence of certain hydrologic considerations of the acid rain phenomenom during the upcoming summer.

A decade of eye-catching headlines has made the term "acid rain" familiar to nearly everyone in the industrialized world. Despite the enthusiasm of the news media, the environmental problem posed by acid rain is widely misunderstood. Some people expect acidic rainfall to dissolve statues and turn green lawns brown on contact. Others assume that some sort of anti-acid-rain pollution control device exists or is in the making. Also, there are instances where major periodicals have mistakenly attributed biotic die-off to acid rain when in fact, the environmental damage was more likely due to old fashioned air pollution.

False notions about acid rain arise because a wealth of knowledge from many scientific disciplines is needed to fully descibe its effects. Research teams have only recently integrated principles from chemistry, biology, meteorology, and hydrology into an explanation of the origin, movement and fate of acidic substances in the environment. It's not a quantitative explanation either, rather, it's an outline of the web of mechanisms that play a role. Numerical models of acid rain behavior have been largely unsuccessful, there are just too many influential random processes involved. However, there is enough background to draw some pointed conclusions concerning the future of acid rain in the earthly ecosystem. These are not speculative conclusions; they seem to follow from this summary of the last thirteen years of acid rain investigations.



Contours of equal rainfall pH or isopleths for March 1979 to April 1980. (Glass and Bridges 1981)

In 1969, the European Fisheries Advisory Commission published an alarming report on extremely acidic conditions that existed in many inland lakes and streams throughout northern Europe. The problem prompted intensified research pertaining to both the cause and the impact of elevated surface water acidity. Major discoveries were made by researchers in Norway and Sweden during the next three years. These two nations emerged as the areas where acidic surface water was most commonly observed. First, it was reported that trout populations had been wiped out in a number of Norwegian lakes. The fish kills were linked to lake acidity by the fact that fish persisted in nearby lakes that had normal acidities.

Tracking down the cause of lake acidification was not as easy as it might seem today. One problem was that acidified and normal lakes existed side by side throughout the regions being studied. Also despite the fact that acidity is easily measured, it is not so simple to identify the culprit acid species.

It has taken ten years to explain most of the inconsistencies and variations in acid rain impact, but in 1972, Swedish and Norwegian scientists

Prevailing winds for January (left) and July for North America.

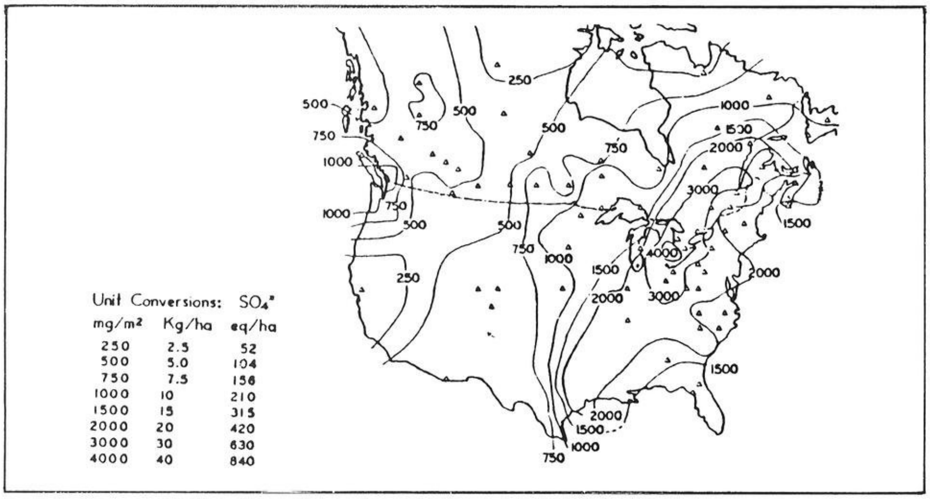
boldly reported that acidic precipitation had increased the acidity of their nations' lakes. World attention was suddenly drawn to the acid rain phenomenon. Soon, its occurrence, causes and effects were being recognized in North America as well. This was an indication that acid rain would become a global problem.

For the most part, acid rain is the result of coal or oil combustion which produces emissions containing large quantities for sulfur and nitrogen oxides which are symbolically written as SO_x and NO_x. These further combine with oxygen to form sulfate and nitrate ions, $SO_4^=$ and NO_3^-, which in turn form strong acids in aqueous solutions. Acidity refers to the concentration of hydrogen atoms that have given up the single electron found in each atom of molecular hydrogen. Acidity is measured using the familiar pH scale where a decrease of one pH unit corresponds to a ten fold increase in the hydrogen ion (H^+) concentration. Sulfate and nitrate form so-called strong acids because they prefer to steal electrons from hydrogen rather than combining with it to form molecules. The result is higher H^+ concentrations thus higher acidities. In reality, H^+ does not occur in nature, but attaches itself to a water molecule and exists as H_3O^+.

Distilled water, in equilibrium with atmospheric carbon dioxide has a pH equal to 5.6. This figure is accepted as the normal acidity of rainfall. Natural air dust in the atmosphere tends to raise the pH in some places. Terrestrial water has a somewhat higher pH, usually near the neutral point of 7.0. Organisms maintain still higher pH levels within their bodies. When one speaks of acid rain or acidified surface water, a pH of 5.0 or less is a typical definition.

As the global extent of acidified water became known, the existence of acid rain rapidly gained acceptance. The pH of precipitation in North America is significantly below normal over the entire eastern half of the continent. The condition is worst across the Great Lakes Basin, particularily in southern Ontario and upstate New York. In eastern North America, the prevailing winds are such that airborne pollutants travel east to northeast across the upper midwest toward New England throughout the year. Coal-fired power generation, auto use, and ore smelting are quite common upwind of New York and Ontario. These activities are also primary SO_x and NO_x sources. The picture is largely the same in Scandinavia. The prevailing winds blow northeasterly over Great Britain, where coal is a chief source of energy. Emissions are carried across the North Sea to Norway and Sweden where wet deposition of sulfate ions as acid rain or snow was first reported. More recently, researchers have documented the phenomenon of dry deposition of acid forming substances. Dry deposition occurs because $SO_4^=$ and NO_3^- are a great deal heavier than atmospheric air, so they tend to settle out quickly.

Up to the point of wet or dry deposition, the acid rain phenomenon is the same for every geographic location. Upon reaching the surface, the terrestrial system offers a great variety of pathways for acidic substances. While drifting in the atmosphere, sulfate and nitrate ions are rarely consumed through chemical or biological processes. Chemicals with this property are called conservative substances. Both sulfate and nitrate are much more conservative in the atmosphere than they are on the surface. This is especially true of nitrate which is a plant nutrient thus, it is often removed



Wet deposition of sulfate ions during April-October 1979 in milligrams per square meter.

from the environment through biological uptake before reaching a major water course. Of course nitrate in rainfall is indistinguishable from that which is naturally available to plants in animal waste, making it impossible to track in the terrestrial system. Sulfate, on the other hand, is of little biological importance. It is not really a conservative substance either, but when it reacts there are tell-tale signs. Sulfate readily combines with metals to form toxic substances such as copper sulfate.

Ultimately, the sulfate ions ends up in solution where each is capable of liberating two hydrogen ions. If this happens in the atmosphere, acid rain results. If not, the net effect is the same once dry deposition occurs. In the former case, current evidence indicates that seventy percent of the sulfate ions are neutralized by other cations that are eager to combine with it. These are primarily calcium and magnesium ions which are both crucial for plant growth. Ionic hydrogen (H^+), is, in contrast to sulfate, very chemically active in nature. There are two important processes by which hydrogen is removed from solution; cation exchange and the presence of alkalinity. Cation exchange is when a metal is replaced by hydrogen in a molecule. Aluminum, manganese, and iron ions are commonly liberated through cation exchange. The aluminum ion concentration is often used as an indicator of acid rain impact because it is usually immobile except in the presence of acids. Aluminum is also toxic to fish and plants. H^+ is also neutralized by carbonate buffering that occurs in soils as well as lakes and streams. The presence of carbonates is an ecosystem's natural defense against acidic conditions. Carbonate alkalinity is only replenished by slow geochemical processes.

The result of all of these ion removal processes is that the effects of acid rain go undetected in many cases. Either the acidforming sulfate or the hydrogen ions themselves are assimilated by the environment. The mechanisms by which they are removed are not infinite however. The possibility of irreversible loss of buffering capacity in lakes and watersheds is one of the most serious potential impacts of acid rain. The watersheds in acid rain regions that have not exhibited elevated acidity are suffering as much environmental damage as the ones that have low pH levels. Hydrogen and sulfate will move more and more freely in the world's watercourses as the environments capacity to neutralize acidity is depleted.

On the supply side, the trend is not encouraging. A modern, 1000 megawatt, coal-fired power plant with emission controls releases 65 million kilograms of SO_x per year. The worldwide annual emission totals 145 billion kilograms. This amount is sure to increase as fuel oil becomes less viable and the hydropower sites run out. The SO_x can remain airborne for days, travelling around the world, always returning to earth in a location other than where it was discharged. The one conclusion that can be drawn based on current evidence is that acid rain will be a global environmental problem requiring unprecedented cooperation to solve. □

Engineer's Library

Zen and the Art of Motorcycle Maintenance

by Robert M. Pirsig

Zen and the Art of Motorcycle Maintenance is a tale of two journeys. The book is, on the most superficial level, a travelogue which describes a father and son's motorcycle trip across half of America. The other, more important journey is the father's search for an identity which electroshock therapy has supposedly taken from him. Just as the pair's literal progress west is indicated by changing descriptions of plains and mountains, the father's progress on his psychological journey is revealed through numerous "Chautauquas" - "popular talks intended to edify and entertain."

In these Chautauguas, the father-narrator, whose background in philosophy, literature, and the natural and applied sciences is extraordinary, introduces and elaborates a series of ideas which lead him, in the final sections of the book, to examine the eternal questions: What is the nature of knowledge? What is goodness? What is truth? What I found and what I think most engineering students will find most interesting are the ideas and examples which the father uses as groundwork for the loftier philosophical inquiries.

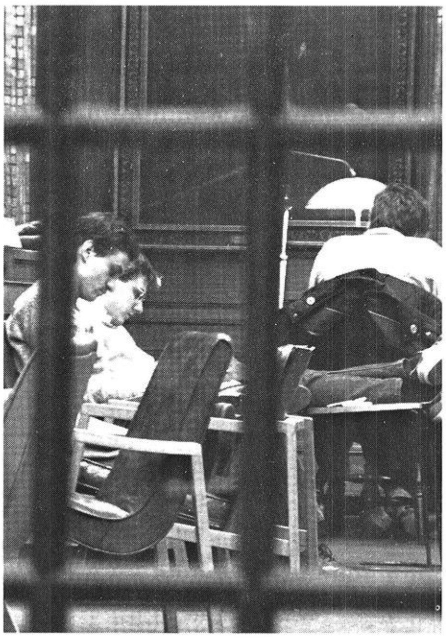


Photo by Matt Ledvina

He examines, for example, the split between "pro-technology" and "anti-technology" people in terms of their different understanding of the world. The understanding of the pro-technologists is classical - the world's underlying form is seen. The understanding of anti-technologists is romantic - they see the world's immediate appearance. A classical activity is motorcycle maintenance; a romantic activity is motorcycle riding.

Each faction views the other's vision of reality with suspicion. To the "pros", the romantic way of understanding is shallow and worthless. To the "antis", the classical way of understanding is boring and uncreative. The father-narrator argues very convincingly that neither vision is entirely correct; the world must be seen in both ways simultaneously for anything of quality - a motorcycle, a book, a government - to be created.

The narrator discourses on countless other topics which might be especially interesting to engineering students. He shows how Zen Buddism can help solve the problem of a torn screw slot on a motorcycle side cover plate. He describes how a mechanical engineer should ideally be educated.

But I'd have to write another book to cover all the complex ideas and illuminating examples contained in *Zen and the Art of Motorcycle Maintenance*. It is, as the *Chicago Daily News* called it, "one Harley of a book" - challenging, thought provoking, a book every future engineer should read. - *Reviewed by Bonnie Buhrow.* □

Photo by Matt Ledvina

Outside reading is essential to the engineer's education.

Human Factors Engineering: Improve Your Grades by Adjusting Your Chair

by Bonnie Buhrow

Bonnie Buhrow takes a personal interest in human factors engineering. At 5' 1", she has suffered a lot because car seats, kitchen tables, and practically every chair in existence is so poorly disigned (that is, designed to accommodate people of excessive height.)

Bonnie is a senior in Industrial Engineering and a valuable member of our staff.

A chair, a desk, and a light bulb - every student, at one time or another, interacts with this simple system in the course of his or her engineering education. If the design of this system is poor - the seat too low, the desk too high, the light insufficient - the student's comfort and studying efficiency are usually greatly reduced.

When a person's immediate physical environment (the chair and desk) or his ambient environment (the light source) adversely affect his performance and comfort, a human factors engineer can come to the rescue. In human factors engineering, measurements of the physical features and functions of the human body and data on human physiological and sensory responses are used to design man/machine systems which are as efficient and safe as possible. In the case of the student/study area system, human factors must be taken into consideration in the design and selection of each of the components - the chair, the desk, and the light source.

The Chair

In order to determine the proper specifications for the student's chair, the human factors engineer would begin by consulting tables of pertinent anthropometric data. Anthropometry is the science of measuring the physical features of the human body, such as height, weight, and limb dimensions, and, over the years, enormous amounts of anthropometric data have been generated by surveys in which representative samples of adult men and women are weighed and measured.

When anthropometric data is used in the design of facilities, vehicles, or furniture, one major principle should usually be followed: *design for extreme individuals.* According to this principle, a minimum dimension, like the minimum clearance for the door, should be based on the measurements of the biggest individuals; a maximum dimension, such as maximum distance of controls from an operator, should be based on the measurements of the smallest people. In practice, however, the "smallest" and "largest" measurements that will be accommodated are not located at the very ends of the measurement scale; instead, measurements at the 5th and 95th percentiles are normally used. Dimensioning designs to include those relatively few individuals whose measurements fall below the 5th and above the 95th percentiles is often just too expensive.

The first and most important dimension to be specified in designing the student's chair is the seat height. Anthropometric data indicate that the popliteal heights (the distance from the floor to the thigh when seated) of the young adult population vary from 14" to 19". When a person is seated in a chair whose seat height is about 2" less than his popliteal height, his weight will be correctly and comfortably borne on his buttocks. If the chair is much higher than this, the front of the seat will exert undue pressure on the thighs, restricting blood flow and painfully compressing the sciatic nerve. If the seat is too low, the seated person will experience lower back pain because the lumbar region of the back will be forced into a convex, rather than the desired concave, position. Because the correct seat height is so important to the sitter's comfort, the best design solution is to incorporate an adjustment mechanism into the student's chair which will allow the seat height to be changed from about 12" to 17".

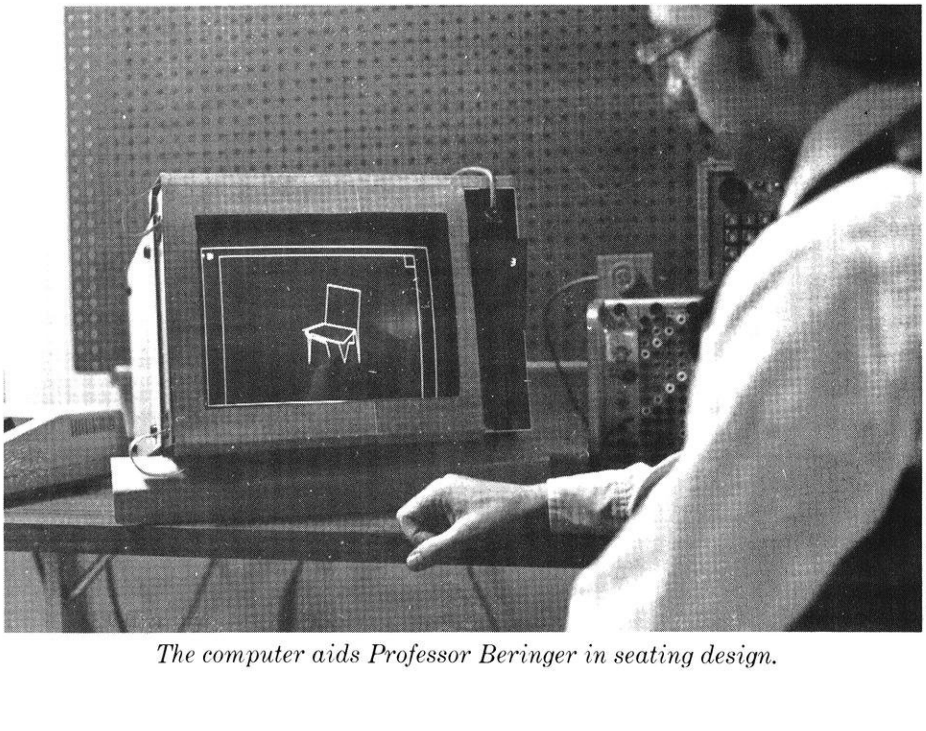
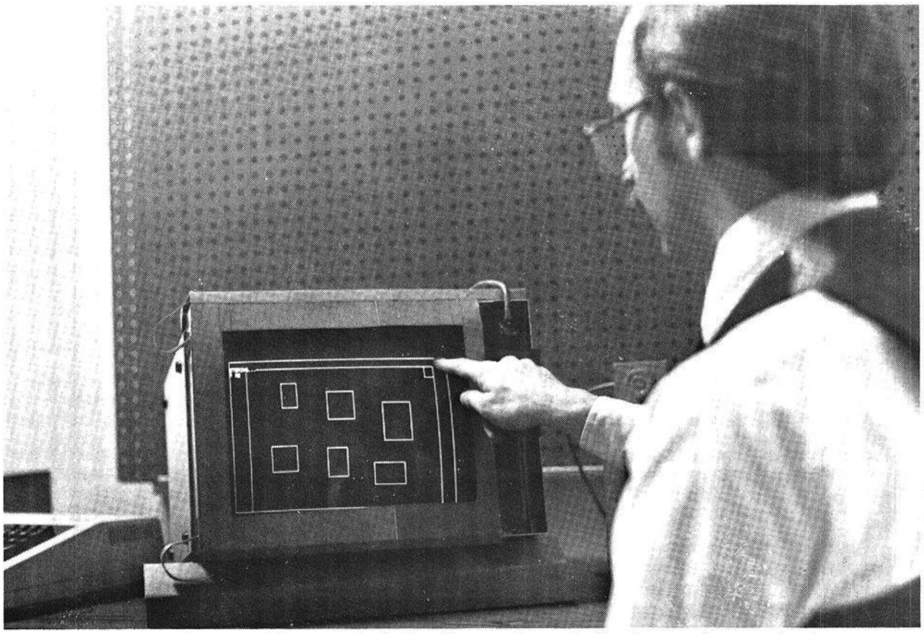


Photo by Banting Wu

The computer aids Professor Beringer in seating design.



UW Human Factors Lab Professor Dennis Beringer demonstrates a touch activated computer terminal.

Photo by Banting Wu

The ideally designed chair should have a backrest about 8" above the seat level to support the lumbar region. This backrest should also be adjustable to accommodate different back shapes.

Both the seat angle and the backrest angle contribute to stabilizing the body weight on the buttocks. For reading and writing at a desk, the best seat angle is about 3 degrees above the horizontal, and the best angle between the seat and the back is about 100 degrees.

Following the "design for extremes" principle, the seat depth should be designed for small persons (maximum depth: 14" to 16"), and the seat width should be designed for large persons (minimum width: 16" to 17").

For greatest comfort, both the seat and the backrest of the chair should be padded. And the chair should permit moderate changes in posture to avoid the muscle fatigue produced by continued static positions.

The Desk

Typically, the height of the student's desk should be determined by his seated elbow height: when a student is performing a task on the work surface - such as writing - his forearm should be approximately horizontal or sloped slightly downward. On the basis of anthropometric measurements of elbow height, desk height should be fixed at about 27". The space under the desk should be large enough to allow free movement of the feet and knees, and the desk top should be thin enough to avoid pressing down on the thighs.

The Light Source

Both the amount and type of illumination needed should be considered in the design of the student's light source.

One unit of measure of illumination is the footcandle. Illumination is related to the luminous intensity of the light source, measured in candlepower, and to the distance between the light source and the area to be illuminated, by the following equation:

$$\text{footcandle (fc)} = \frac{\text{candlepower (cp)}}{D^2 \text{ (distance in feet)}}$$

A one cp source at one foot produces 1 fc; at two feet, the illumination is reduced to $\frac{1}{4}$ fc. Therefore, both the intensity and location of the light source must be taken into account when calculating whether or not adequate illumination is being supplied.

The illumination standard for reading and writing recommended in the *Illuminating Engineering Society's Lighting Handbook* is 70 fc. If illumination falls much below this level, the student can experience eye fatigue, headaches, and decreased concentration. But even when the illumination level is sufficient, the student's performance can be hampered by other light-related factors. Chief among these other problems is glare.

Glare is experienced by a person when a brightness much greater than the level of luminance which his eyes have adapted to appears in his field of vision. Direct glare is caused by the light source itself, while indirect glare is produced by the light source's reflections from highly polished surfaces.

Direct glare can be reduced by using indirect or diffuse light sources rather than direct lighting. A good choice of lighting for the student would be a florescent desk lamp, which could provide the necessary level of illumination while diffusing light from the source to minimize glare and discomfort.

To reduce indirect glare, tasks should be performed on surfaces which will diffuse light rather than directly reflect it into the individual's eyes. The student's ideal desk should not, therefore, have a highly polished surface.

By incorporating human factors into workplace design, an engineer can provide the student with a correctly adjustable chair, a desk of the right height, and a light source which will maximize reading efficiency. If, after this improved design is implemented, the student still experiences discomfort while studying calculus or physics, he or she should put the blame on the course material and not on the study area. □

Fluid Phenomenon in Reactor Cores

by Chris Thron

Chris Thron is a UW Mathematics graduate student who completed his undergraduate education at Princeton University. Last summer, Chris joined a team of scientists at Dartmouth College who were engaged in the research of fluid behavior in reactor cores. In this article, Chris presents the mathematical description of the spray contraction phenomenon, which was his primary interest during last summer's research.

The testing of hydraulic cooling systems in Boling Water Reactors (BWR) has revealed the bizarre fluid phenomenon of spray contraction. If a nozzle sprays cold water into a cavity where water and steam coexist at high temperature and pressure (as in a BWR core), the angle of spray is small compared to the fluid's behavior in air (see photos).

The contracted spray covers less surface area than expected, thus reducing a system's cooling capacity. The emergency spray cooling system of a BWR core has exhibited this contraction. This presents the danger of the core overheating in an emergency situation because a smaller area of the core than expected is being sprayed with cool water. Intuitively, spray contraction is well worth studying to minimize its effect and insure safe reactor design.

A team of engineers at Dartmouth College, led by Graham Wallis and Horst Ricter, is studying the spray collapse phenomenon, both experimentally and theoretically.

A 1 : 10 scale model of a reactor core vessel has been built which can tolerate pressures of more than 100 psig. This model was used to obtain extrapolated correlations to behavior in a full-scaled reactor. Spargers provide steam, and various nozzles can be mounted at the top to spray water into the cavity. A specially designed mechanical arm can carry instruments to different regions in the spray to measure water drop size, velocity and temperature.

Tests of various nozzle designs are now being conducted. Some of these nozzles spray the water with a "twist", as does a shower massage. It is hoped that the centripetal force in the rotating spray will conteract the collasping effect.

Theoretical progress has also been accomplished. A mathematical model has been developed which attempts to simulate the spray. Gravity, drag, and stream compressibility effects have been neglected for this theoretical spray. The nozzle is idealized into rings of point sources for water drops (see fig. 1). Each source emits drops of uniform size, temperature, and velocity at the same rate. Droplet emissions are staggered so that artificial correlations between drop sources are avoided (see fig. 2).

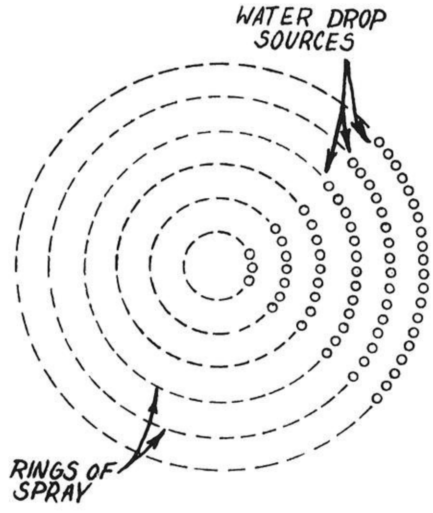
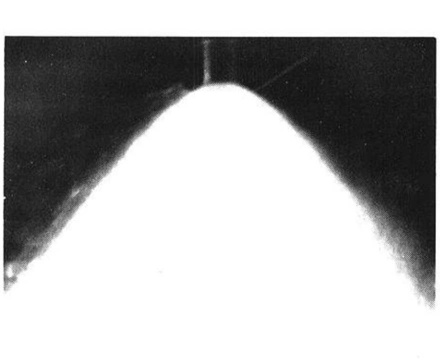
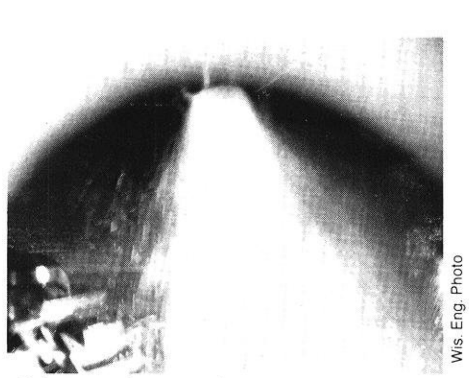


Figure 1.

The drops in the idealized spray attract one another with an inverse-square force, dependent on parameters made evident in the following argument: Consider a single droplet in a steam environment. Steam condenses on the drop, causing a steam flow directly toward the center of the particle. Remembering the steam is assumed to be incompressible, the (divergenceless and radially symmetric) flow velocity will vary inversely as the square of the distance from the particle center (see fig. 3).



Disc nozzle, 20 psi, low condensation rate.



Disc nozzle, 20 psi, high condensation rate.

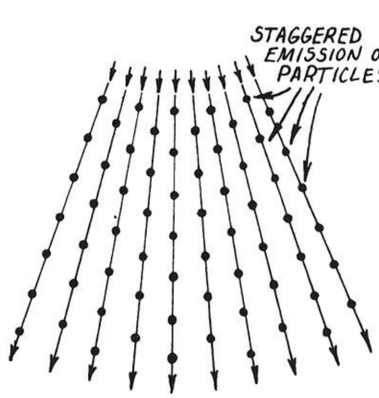


Figure 2.

Now introduce another water drop a distance R from the first. Steam flowing toward the first drop will condense on the second. The rate of momentum transfer from the steam to the second drop will be proportional to the velocity of steam induced by the first drop:

p = momentum of second drop

$\frac{dp}{dt} = bv$ = force between drops

b = some constant

Since the constant b depends only on the rate of steam condensation on the drop, the contractive force between the drops depends on the steam and water temperature, and the steam pressure.

Up to this point, we have only discussed the force between two isolated water drops in a steam atmosphere. In our spray, the drops are no longer isolated, but we assume the same inverse-square force holds between drops. (It is not clear how realistic this assumption may be, and only experiment will answer this question.)

The theoretical model does have the preeminent virtue of being easy to simulate on the computer. A BASIC program was written to find the drop trajectories by iteration. Specifically, the drops were first assumed to move in straight lines from the point source holes; then corrections to the paths were calculated based on the straight line positions. The model predicts an umbrella-shaped spray (see fig. 4). (This prediction has not yet been compared quantitatively to empirical results, but there is qualitative agreement.) The computer program is adaptable enough so that some of the aforementioned neglected effects can be added in.

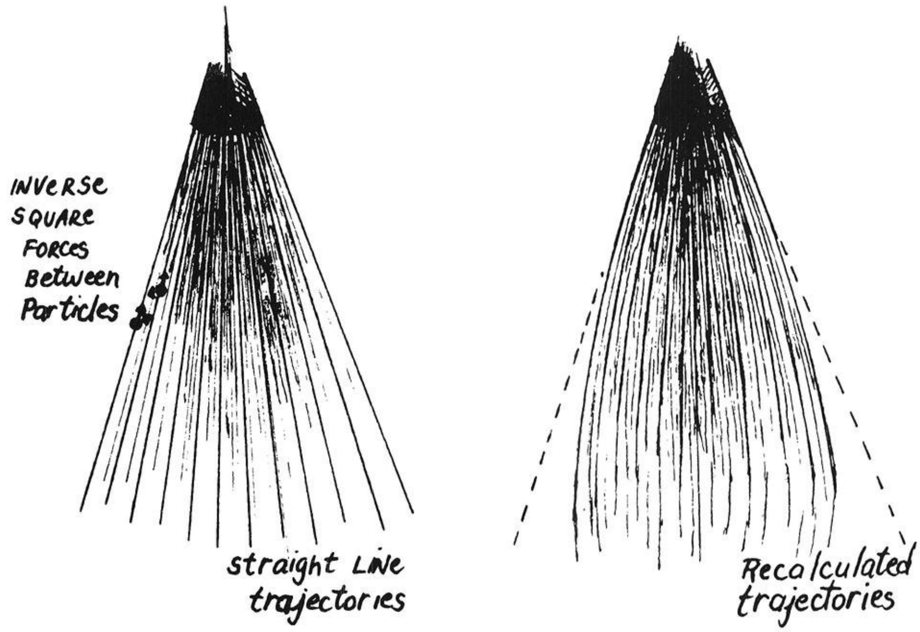


Figure 4.

$\vec{V}_s(\vec{R})$ = steam velocity at $\vec{R}$

$\vec{V}_s(\vec{R}) = \frac{a}{|\vec{R}|^2}\left(\frac{\vec{R}}{|\vec{R}|}\right)$ a = some constant

where $|\vec{R}| = (x^2+y^2+z^2)^{1/2}$

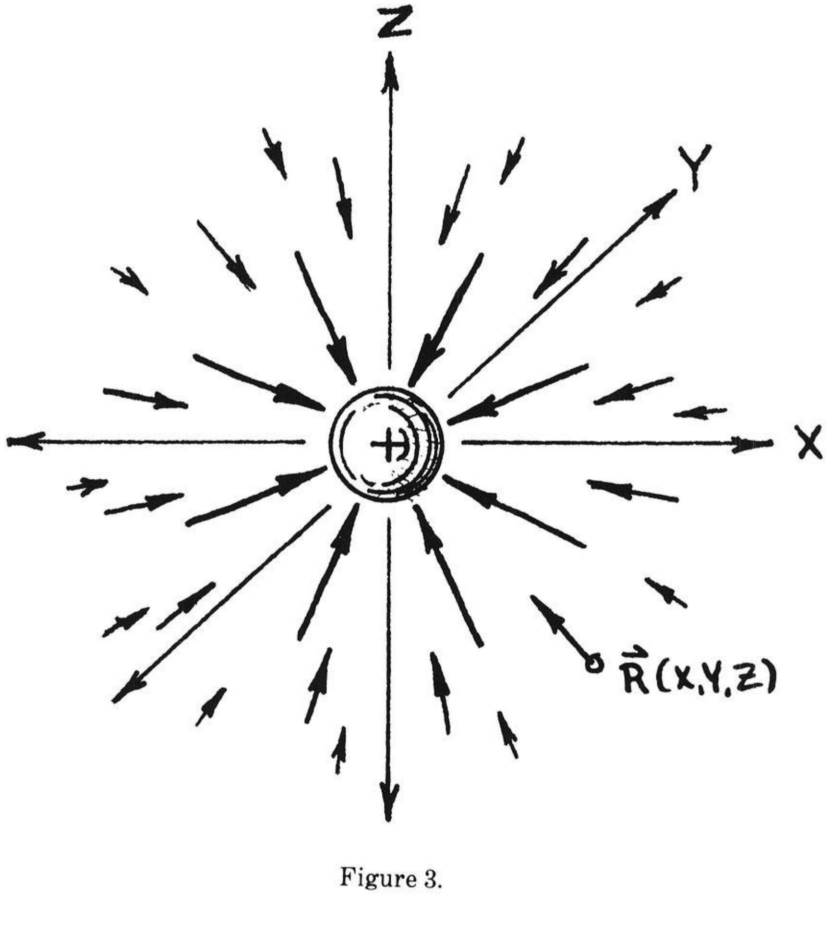


Figure 3.

Spray contraction is not the only sophisticated fluid-mechanical effect of interest to nuclear reactor design. Scientists are interested in the flow behavior when water and steam coexist. At high temperature and pressure, water can instantaneously change into steam; this is called flashing. Because of flashing, an operator can be unsure of how much water is in a system to cool the core.

For more technical details, the reader is referred to *"The Status of Boiling Water Reactor Safety Technology"* by R.T. Lahey, Jr., in *"Thermal and Hydraulic Aspects of Nuclear Reactor Safety,"* vol. 1, (ASME, 1977).

Unanticipated fluid behavior and the high risk involved speak forcibly for a cautious approach toward the engineering of BWR hydraulics systems. By studing fluid phenomenon such as spray contraction and flashing, engineers can confidently design safety systems to ensure effective cooling of nuclear reactors. □

The Economics of Space Industrialization

by Tom Kuzdas

In this article, Tom Kuzdas reviews the great economic potential of our nation's space program. A sophomore in Applied Math, Engineering, and Physics, Tom is a member of Triangle Fraternity, and of the L-5 Club (a pro-space expansion organization).

There are those who ask, "Why do we waste money on space suttles and space probes when we have so many problems on earth to solve?" These people have not realized the worldwide benefits that have stemmed from our space program and its spin-offs, and that NASA is one of our nation's greatest assets.

Most people of the world have benefitted from the use of satellites, and many markets have been generated by technologies created by NASA programs. In the future, the world can expect to continue to benefit from space programs. The space shuttle will make the concept of space-born industry feasible.

Services offered by NASA satellites affect many people's lives. Weather satellites, by sighting hurricanes and offshore tropical storms, have saved countless lives and millions of dollars in property. Satellites monitor the atmosphere for pollution with the use of infrared photography. These satellities can also detect and map crop infestations on earth. Ships and submariens use navigational satellites to locate themselves on the earth. Observation satellites have enhanced world stability by permitting the observation of nuclear missiles and have made it possible for the SALT treaty to be enforced to the satisfaction of both sides. Communication satellites have also made it easier for us to telephone overseas.

The innovations and improvements of equipment needed to land men on the moon, developed during the years of the Apollo Space Program, have had a tremendous effect on many other areas of science. In the field of medicine, we have the Ultra-Sound Stethoscope, which is a product of the Apollo investigation of sonar. Studies of X-ray topography and computer graphics effected the development of the CAT Scan (Computerized Axial Topography). Cargo restrictions during Apollo missions required computers to be light, small and capable of operating at very high speeds. To satisfy these requirements, the development of the Integrated Circuit was accelerated, and today the hand-held calculator is an everyday item.

Economic studies have shown that for every dollar put into NASA, between six and fourteen dollars of growth in this country's GNP has resulted. (The range of the estimates is a result of several independent studies.) Few programs can boast such a high return. One has to wonder why our politicians, past and present, are reluctant to increase NASA funding to stimulate the economy.

In the late sixties, a professor at Princeton posed this problem to his freshman physics class: "What is the largest structure that we can build in space today assuming no major breakthroughs in research and development, and assuming we had the space shuttle?" The answer was that we could build structures miles long with a mass of several million tons.

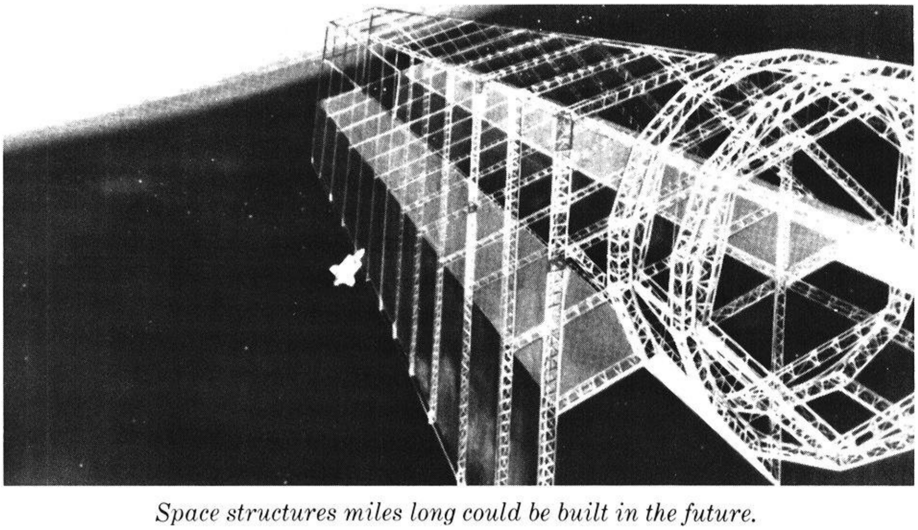
There is great potential for commercial space expansion. Markets in the foreseeable future include information services, energy, space manufacturing, and tourist services.

New information services created could include tele-conferencing, portable telephones, a national information service, and electronic mail. By the year 2010, the combined annual income from these services could be as high as $37 billion.

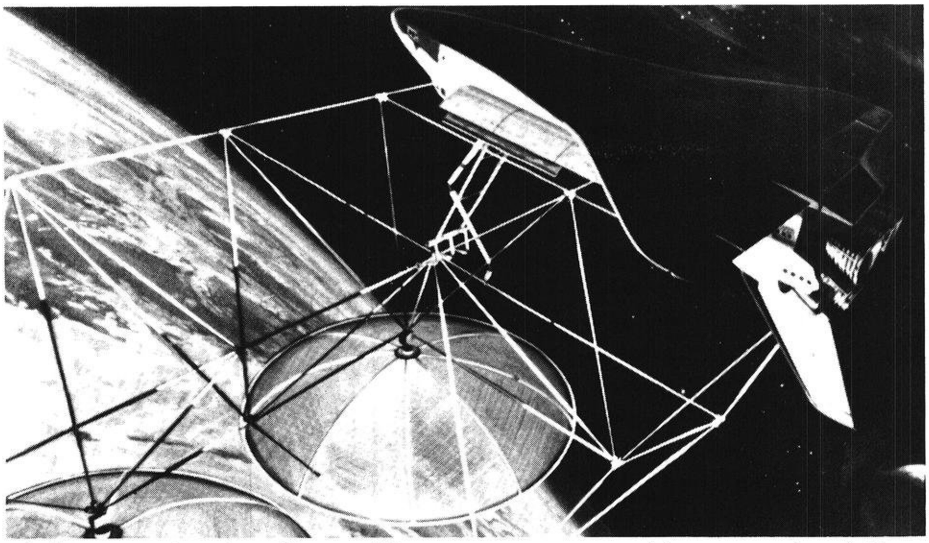
There is energy potential from space expansion. One idea is to build huge power plants in space and convert the sun's energy into microwaves and send these microwaves to receiving stations on the earth's surface, where they would be converted into electricity and fed into the nation's power grids. Several methods of building these power plants have been proposed.

Peter Glaser, the father of the Solar Satellite Power Station (SSPS) concept and president of Arthur D. Little Inc., has proposed that we build the power stations by shipping their components into space using huge rockets and assembling them in orbit. Using this proposal and charging a base rate of 2.7 cents per kilowatt-hour, the annual revenue in the year 2010 could be $50 billion, according to Glaser.

The second proposal is from Professor O'Neil of Princeton. O'Neil proposes building the power stations in huge space factories using material mined from the moon. In the year 2010,



Space structures miles long could be built in the future.



Artist conception of a self-assembling space structure used here as a relay station.

there would be approximately sixty 10 gigawatt power plants operating. (The largest power plants on earth are at most 2 to 3 gigawatts.) If Peter Glaser's 2.7 cents per kilowatt-hour were charged, the annual revenue in 2010 could be as high as $100 billion. If the rate was to start at 1.15 cents per kilowatt-hour and drop after the first year of operation, the annual revenue in 2010 would be about $30 billion.

Many products could be manufactured in celestial factories. The space factories would have many advantages over their terrestrial counterparts due to lowered atmospheric pressure and gravity, as well as ready access to materials and energy necessary for growth.

Products produced by such factories could include drugs and pharmaceuticals, semi-conductor electronic materials, high strength magnets, superconducting materials, fiber optics, metallics, perishable cutting tools, new bearing materials, and jewelry. The combined annual revenue in 2010 would be over $6 billion.

People services include space tourism and a space hotel. This would have an annual revenue of only $0.1 billion in 2010. Assuming we expand our space program very soon and follow Prof. O'Neil's plans, the total revenue for 1985 to 2010 could be as high as $580 billion. However, for such profits to become a reality in 2010, it is critical that our space program be expanded before 1985. The figures given in this study are somewhat optimistic.

At the time of his study, Prof. O'Neil concluded that the cost of this venture would range between $50 and $200 billion. Economist Mark Hopkins, a Harvard graduate, found in his own study that if the F1 Flyback (a design rejected by NASA in 1970 because of budget constraints) were used, the cost would be $106 billion. This cost would include the research and development of the F1 Flyback. Pete Vjak of Science Applications Inc., predicted a cost of $178 billion if the space shuttle were used as the cargo carrier. Hopkins' figures were later verified by Gerald Driggers, former president of NASA. All the studies assume a starting date in the early 1980's.

For the $106 billion price tag, the United States would get one space station, one lunar mining base, a fleet of 6 to 10 F1 Flybacks, and several space shuttles. A space city is a more accurate description as the space station's mass would be between 3 and 4 million tons and would support a workforce of 10,000 workers. Using carbon, hydrogen and nitrogen from earth and oxygen from the lunar soil, the colonists would grow their own food in a closed ecosystem. Using a mass driver (O'Neil 1977, Heppenheimer 1977), the mining base on the moon would be able to mine and ship over 600,000 tons of ore per year by the turn of the century.

Where would this country come up with the $50 to $200 billion to fund this project? In the worst case, the investment would be 1% of the country's GNP for ten years. NASA's budget is $6 billion per year at the present time. Suppose the United States could pay only half the cost? Then Japan, Germany and France might be interested in investing the remaining $100 billion. Hopefully, the bonds of international cooperation would be strong enough to invite the Soviets to participate also.

In the studies mentioned, the colonies (naturally, part of the work force from the first colony would build a second, and a third, etc. would be able to pay back the money needed for construction, plus the interest accumulated during construction within a reasonable time frame. That such an enterprise could pay off such a debt at all is a tribute to the market potential that space expansion has to offer. □

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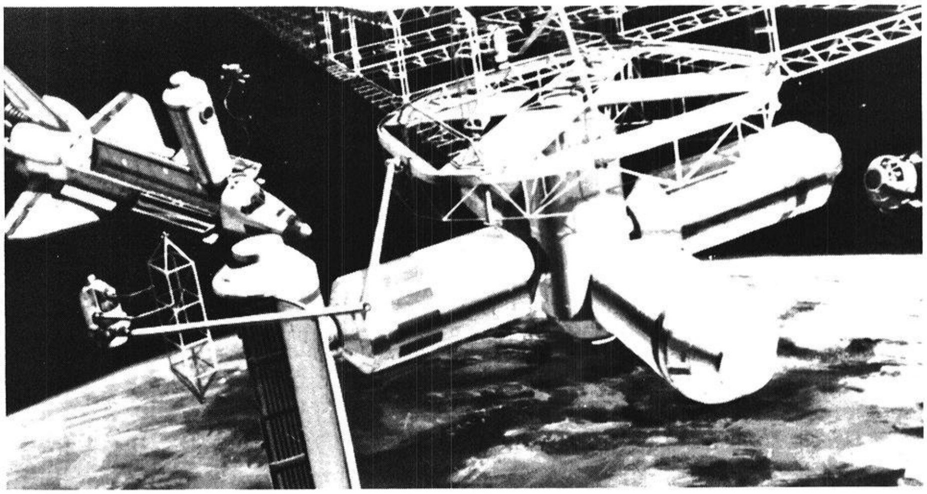


Pictured above is a proposed extra-terrestrial communications center.

Bits & Threads

Women engineering students are eligible for up to $10,000 in loans from the Business and Professional Women's Foundation (BPW). The loans provide for tuition, fees, and related expenses such as child care and transportation. Eligibility requirements include financial need, U.S. citizenship, and status within two years of graduation. Both work experience and academic achievement will be considered.

Completed applications are due by May 15, 1982, so interested students should act quickly. For applications and/or futher information, write to: Loan Fund for Women in Engineering Studies, BPW Foundation, 2012 Massachussetts, N.W., Washington D.C. 20036.

U.S. electronics companies have formed a committee to wrestle with a serious problem facing the industry: an expected shortage of 129,000 qualified candidates for engineering jobs due to open up between now and 1985. The committee's proposals center on ways of enabling colleges to train more electronics and computer-science engineers. The most controversial recommendation would ask firms hiring graduates to pay the colleges a bounty: $2,000 for a Bachelor of Science, $3,000 for a recruit with an M.S. degree. -- Newsweek.

The Tennessee Society of Professional Engineers and the Consulting Engineers of Tennessee have launched the "Let's Play Engineer" national toy contest.

"Let's Play Engineer" will run for three months and end with an announcement of a national winner in late summer, 1982. "This contest has been developed to promote engineering at a point in a child's life when he or she is inquisitive and wants to learn and explore," explained Mary D. Shahan, Executive Director of the two state engineering societies. "In addition, it will enhance the engineers' image with the general public and make all engineers aware of their responsibilities and important roles in their communities."

The winning design entry will be selected by a panel of judges from various engineering disciplines as well as from the toy manufacturing field. The winning designer will be awarded prizes totalling $5,000 and will receive commission once the toys are placed on the open retail market.

For complete rules and information, contact Professor George Sell, 243 Mechanical Engineering Building, advisor to the student chapter of the Wisconsin Society of Professional Engineers (WSPE).

RMJ Photo

Pictured above is the Engineering Student Art Collection. The paintings and photographs are available to only engineering students to rent for $3 per semester. The collection gallery is located at the south end of the Kurt F. Wendt Library.

Much quoted findings by MIT's David Birch show that firms with fewer than 250 workers created 90% of the nation's new jobs in the 70's. The National Science Foundation found that in the 20 years preceding 1973, small firms produced 23 times as many innovations per research dollar as large firms.

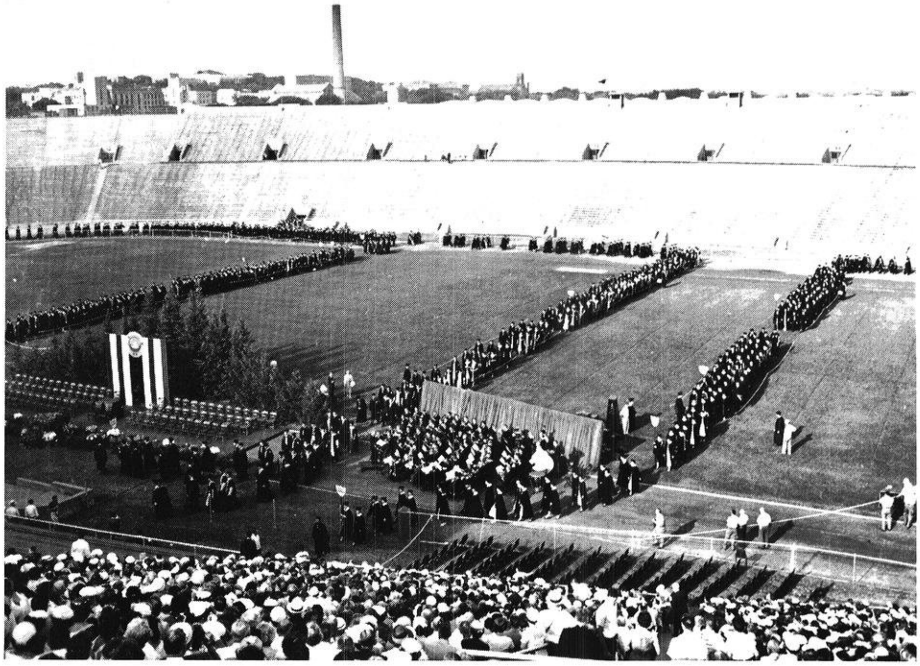
New York City's pending Westway project will be a four-mile highway running along the Southwest edge of Manhattan. It's slated to cost $2.2 billion. That's $550 million a mile - not only more expensive than any highway ever built (the previous record-holder was $145 million) but more expensive than any subway. Westway's four miles are also scheduled to take ten years to complete. Under New York's penny-pinching plan, Westway is programmed to cost $8,680 per inch. -- *The Washington Monthly.*

The Amoco Foundation has announced that new doctoral fellowships in Chemical Engineering will be granted to the University of Wisconsin and other major colleges. These grants are being created to encourage more engineering students to seek doctorals. The fellowships are part of the Amoco Foundation's, which is financially supported by the Standard Oil Company (Indiana), multi-million dollar effort to relieve a nationwide shortage of engineering faculty and graduate students.

The yield in TNT equivalent of the strategic nuclear warheads held by all the world powers in 1978 would fill a freight train 3.5 million miles long, each car packed end to end, floor to ceiling, wall to wall. This is 3.8% of the average distance to the sun. At the current population, this amounts to about 3.5 tons of TNT for every man, woman, and child on earth, or one Hiroshima-sized bomb for every 6,000 people on the planet. This destructive power, which does not include the MX system, grows exponentially with time. -- *HTPFF Newsletter.*

The Reagan Administration is mulling new ways to cope with the increasing misappropriation of sophisticated U.S. technology, often by espionage and thievery. One hitch is that information on some high-tech U.S. equipment which has fallen into Soviet hands can't be shown to U.S. engineers and scientists because, ironically, it is still secret. Some officials are trying to get such data declassified so that U.S. electronics experts can see for themselves what the Soviets have pilfered. To help ease another part of the problem, Washington may ask for agreements that might prevent the diversion of advanced U.S. gear to the Soviet Union from Third World manufacturing plants. -- Newsweek.

The Environmental Protection Agency is working on proposals that would allow the dumping of low-level radioactive wastes in the ocean. In brazen defiance of the axiom that a lot of a little makes a lot, an EPA official said, "We are running out of available space...so why not use the ocean? The ocean has a lot of background radioactivity in it anyway." What he neglected to mention was a major contributor to that background radioactivity--tens of thousands of barrels of nuclear waste discarded in the world's oceans over the past 35 years. The U.S. was finally forced to stop the dumping in 1970 when, prompted by protests from Canada and Mexico, EPA studies showed that edible marine fish were being contaminated. In fact, of all the options under serious consideration during the last decade for the dumping of about 4,500 tons of the nation's spent nuclear reactor fuel, the sea has been considered the least attractive. Recent research has not conclusively decided on any one alternative, but so far disposal in salt domes and other geological formations and processes that would solidify the liquid waste into glass seem the safest long-term solutions. But we can't be certain of that if we rush to the seas while skimping on necessary research programs at the EPA and the soon-to-be defunct Department of Energy. -- *The Nation.*



Wis Eng Photo

Commencement ceremonies in the 1950's.

Wis. Eng. Photo

View of University Hill from Lake street photographed in 1880.

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