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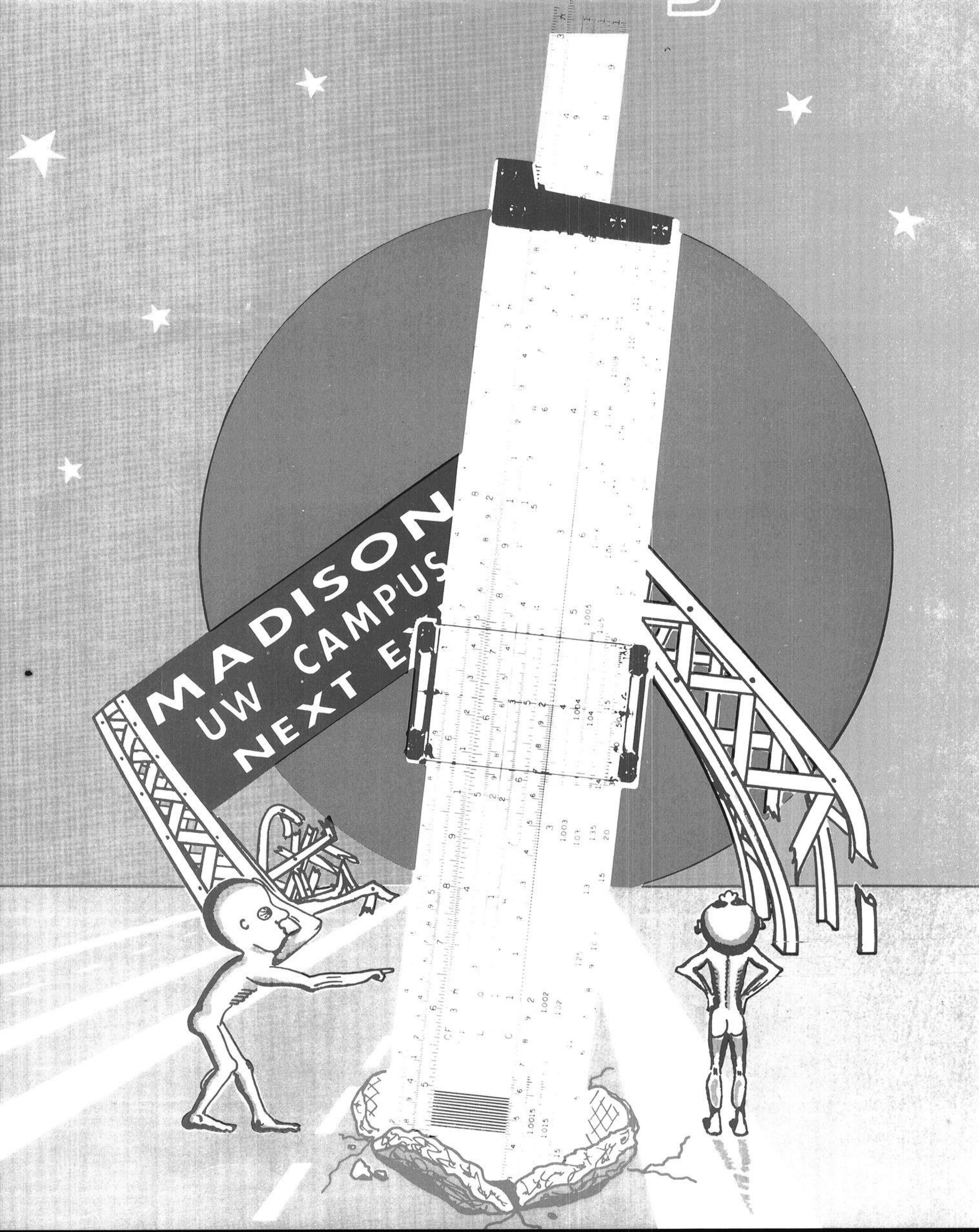
# wisconsin engineer



# "They encourage us to look for original solutions to problems. This sparks inventiveness."

Bill Greiner, Western Electric

Bill Greiner's problem: shaving 10-14 seconds off one operation in the manufacture of integrated circuits, while reducing error factor below .001 inch.

Bill is a staff member at Western Electric's Engineering Research Center, working primarily with the handling and testing of integrated circuits.

Bill came to Western Electric in 1968 after receiving his MS from MIT. He earned his BS in Mechanical Engineering at Yale.

"My work here has given me a better appreciation of the problems in manufacturing," said Bill. His automatic TV system for the alignment of integrated circuits is a good example.

At one phase of the manufacturing process, operators must correct alignment of integrated circuits by hand—a job that took up to fifteen seconds, and was accurate to only .001 inch in x and y, and to one degree in rotary.

What Bill did, essentially, was design and build a small dedicated computer that completely automates the process. An operator can push a button to align the integrated circuits automatically. A TV camera enlarges the image in silhouette form, scans the pattern, and feeds the voltage signal into Bill's computer. The computer calculates the position measurements and triggers a stepping table to correct the alignment.

The correction time is reduced to one second, the error factor to .00025 inch in x and y, and ½ degree in rotary.

Bill finds the challenge of electronics and logic design extremely stimulating. "We're not channeled: we have a chance to get involved in a variety of fields."

What does he find most satisfying about his job at Western Electric? "Well," said Bill, "I look for an amount of responsibility. And here I'm encouraged to take it."

**Western Electric**

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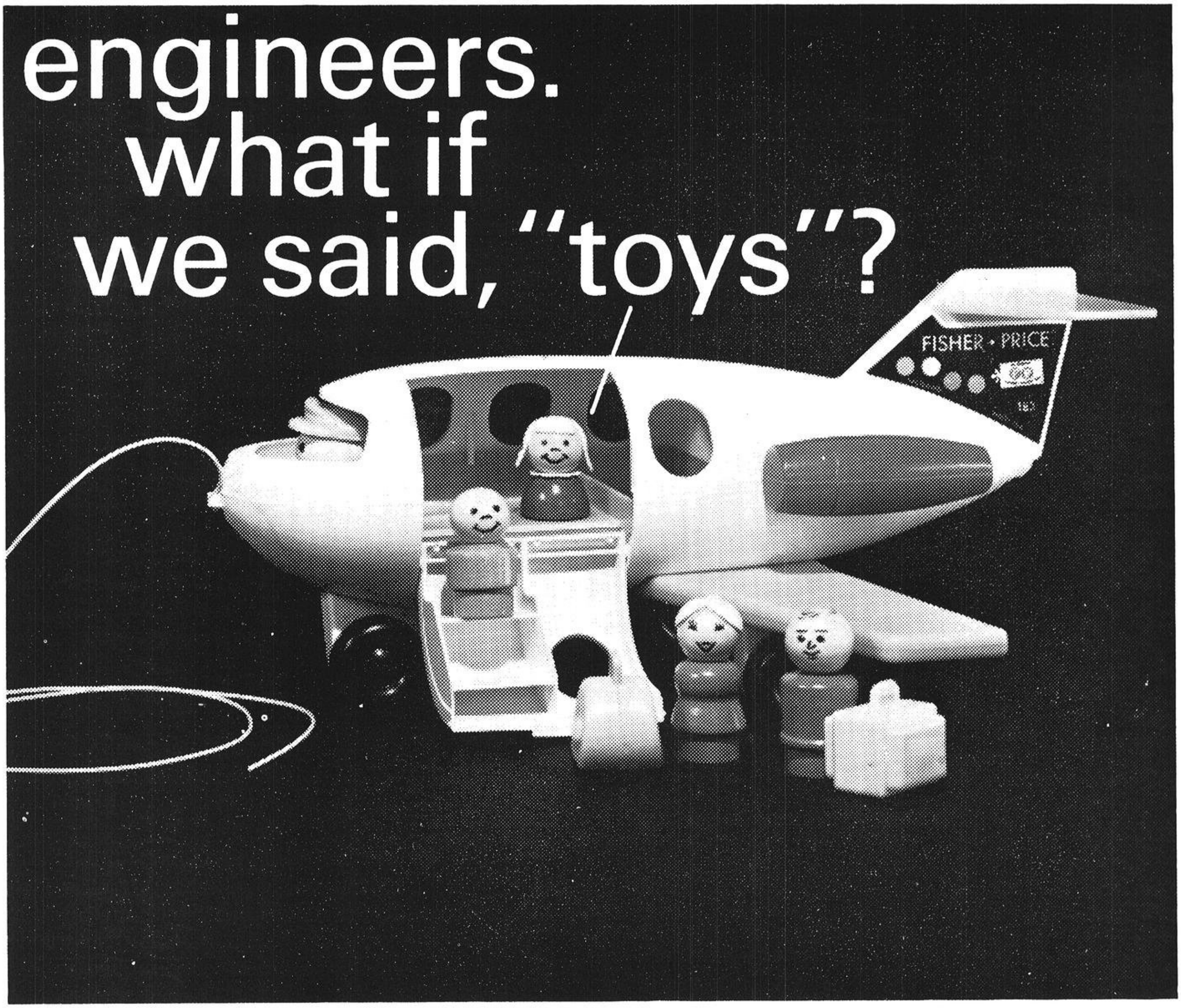
engineers.
what if
we said, "toys"?
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You'll never have to ask what's new
if you work for a company like this.

> *"We are drifting toward a catastrophe beyond comparison. We shall require a substantially new manner of thinking if mankind is to survive."* – (**Albert Einstein**)

## CONTENTS:

# wisconsin engineer

MEMBER OF ENGINEERING COLLEGE MAGAZINES ASSOCIATED

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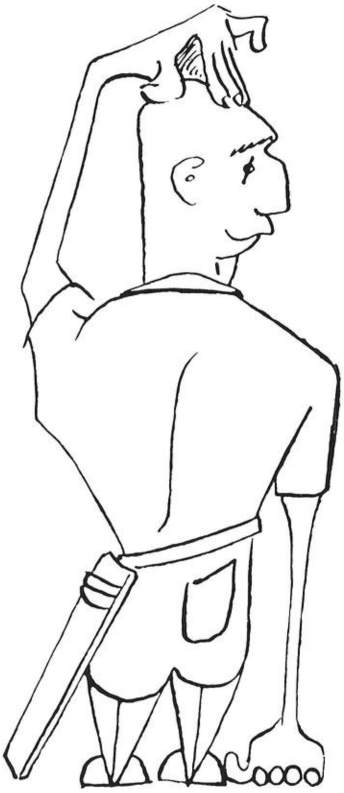
# Puzzles



1. What are the next two numbers in this progression: 61, 52, 63, 94 . . .

* * * * * * * *

2. The next progression was presented by Tom Hauge as a quiz to a (hint) computer science class. Find the last number: 10, 11, 12, 13, 14, 15, 22, 101, 1010, ? . . .

* * * * * * * *

3. Given a 10 gallon container full of water, one empty 7 gallon container, and one empty 3 gallon container, divide the 10 gallons into two equal portions.

* * * * * * * *

4. With the following configuration of matchsticks, move one and improve the approximation.

$$III \simeq \frac{XXII}{VII}$$

5. Given $A^2 + B^2 = C^2 + D^2$
Find the lowest set of integers which makes the equation true. Note, that zero squared is undefined.

* * * * * * * *

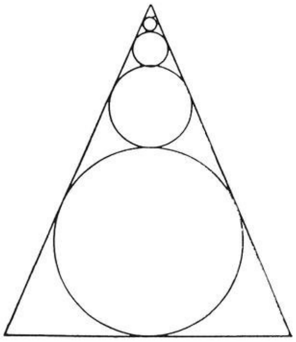
6. A monkey and his uncle are suspended at equal distances from the floor at opposite ends of a rope which passes through a pulley. The rope weighs four ounces per foot. The weight of the monkey in pounds equals the age of the monkey's uncle in years. The age of the uncle plus that of the monkey equals four years. The uncle is twice as old as the monkey was when the uncle was half as old as the monkey will be when the monkey is three times as old as the uncle was when the uncle was three times as old as the monkey. The weight of the rope plus the weight of the monkey's uncle is one-half again as much as the difference between the weight of the monkey and that of the uncle plus the weight of the monkey. How long is the rope? How old is the monkey?

* * * * * * * *

7. There are four flies on the four corners of a square. Each one faces the fly next to him, in a clockwise direction. Each starts walking at a certain instant, always walking directly toward the fly he was originally facing. All walk at the same speed. When they meet at the center, how far has each walked?

* * * * * * * *

8. Circles are stacked so as to fit in a triangle of 8” base and 10” altitude as shown:



Each circle is inscribed in the triangle and resting on the circle below.

There are an infinite number of circles involved.

a. What is the sum of the circumferences of all the circles?
b. What would be the total surface if the figure represents spheres in a cone?
c. What fraction of the triangle's area is covered by these circles?

*(Answers on Page 18)*

# *Editorial —*

". . . where grievances pile high and most of the elected spokesmen represent the Establishment, violence may be the only effective response."

Supreme Court Justice
William O. Douglas

"Only an alert and knowledgeable citizenry can compel the proper meshing of the huge industrial and military machinery of defense with our peaceful methods and goals, so that security and liberty may prosper together."

Dwight D. Eisenhower

"A free government with an uncontrolled power of military conscription is the most abominable contradiction and nonsense that ever entered into the heads of men."

Daniel Webster

"Overgrown military establishments are, under any form of government, inauspicious to liberty, and are to be regarded as particularly hostile to . . . liberty."

George Washington

[***]

# Earthbound Explorers Probe Lunar Rocks

by Kerry Brookman

CAN A THIMBLEFUL of brownish powdered rock or a polished stone section the size of a quarter reveal something of the origins of the moon and earth?

The possibility that they indeed can was put to a rigorous test last fall when 141 scientists, among them University of Wisconsin chemist Larry Haskin and geologist Eugene Cameron, began analyzing small samples of Apollo 11's 70 pound rock cargo.

The samples had already been found by NASA scientists to be igneous basalts formed from molten volcanic lava or magma. Haskin's and Cameron's studies began from that point they analyzed mineral composition and trace element concentrations of the lunar samples with the goal of discovering conditions and processes of rock formation on the moon.

### Trace Elements Studied

On seventh floor of the Madison campus's New Chemistry Building, Haskin, post-doctoral fellow Ralph Allen and graduate student Philip Helmke spent much of last fall analyzing the lunar rocks for trace chemical elements, those non-essential to the structure of a mineral. The quantity of these trace elements is significant to geochemists because it tells something about the liquids from which the rocks crystallized.

Haskin explains the presence of the non-essential elements: "When rocks form, their minerals are made of the elements most abundant in the parent material. Minute quantities of other elements are also present when the minerals form and have to find a place for themselves. Some are trapped inside the minerals, others may be in cracks and along mineral grain boundaries."

Concentrations of these elements are low, he adds. Extraction of a quantity of gold weighing the same as a penny would require all the gold from 1,000 tons of lunar rock.

### Rocks Irradiated

Haskin used neutron activation analysis, a technique requiring only tiny amounts of powdered rock and soil, for his studies.

The procedure begins with irradiation of the samples in a nuclear reactor, Haskin explains. During irradiation, neutrons generated in the reactor, that formed the lunar rocks were not in contact with feldspars during the final stages of development but, on freezing, produced rocks that contained a considerable amount of feldspar.

"That requires," says Haskin, "a more complex history of the lunar rocks than some hoped would be the case."

The second factor of interest in the europium depletion is that the same deficiency is found in submarine basalts from the earth's mid-ocean ridges, although the depletion on the moon exceeds that of earth basalts.

A more striking similarity is the relative abundances of the other rare earths – their concentrations are much the same in both lunar and submarine ridge basalts. This suggests that similar chemical processes operate in rock formation on the moon and at the ocean ridges, Haskin observes.

In contrast, rare earth abundances in basalts found on continents and oceanic islands do not match those in the lunar material.

### Opaque Mineral Studies

In a basement lab in Science Hall, Eugene Cameron began delving into the structural mysteries of the lunar samples last October.

He looked at the textures and compositions of the opaque minerals. Considered together, the minerals and their textures give a good indication of the conditions and processes of rock formation because each species develops only under a certain range of heat and pressure.

Cameron's samples arrived in the form of polished sections, and the first step in his analyses was to examine the sections under a reflecting optical microscope.

### Microscope and Microprobe Used

The reflecting microscope permits viewing of opaque minerals by directing a beam of light onto the polished section. The opaque crystals reflect the light, allowing the number of minerals present and, to some extent, their concentrations and composition, to be determined.

Exact composition of the lunar minerals had to be determined with a more sensitive instrument, the electron microprobe. Like the neutron activation method used by Haskin, the microprobe can observe trace amounts of an element.

The same polished sections studied with the reflecting microscope can be placed in the high-vacuum chamber of the microprobe. Each mineral grain to be analyzed is brought into the path of a beam of electrons emitted by a tungsten filament. Two systems of magnetic lenses can focus the beam to a diameter as small as 1/25,000 inch for analysis of unimaginably tiny mineral grains.

When the electron beam hits a mineral crystal, x-rays of characteristic wavelength are emitted by atoms of each element present. Concentrations are found by measuring the intensities of the x-rays and comparing them with intensities of x-rays emitted by standards of known chemical composition.

## New Compounds Found

From these studies, Cameron found several new minerals. One, a titanium-iron oxide quite rich in titanium, was dubbed armalcolite in honor of the Apollo 11 crew. Ilmenite, the opaque mineral dominant in the lunar samples, is also a titanium-iron oxide but has a lower titanium content than armalcolite.

Second in abundance was troilite, an iron sulfide containing globules of cobalt-bearing native iron. This mineral association is not found at all on earth. Its formation on the moon must be due to very low oxygen and sulfur pressures in melts from which the rocks crystallized, Cameron explains.

That water is completely lacking in the lunar minerals was Cameron's third major finding. Most mineral deposits on earth formed in systems with abundant water, he notes, and many of the mineral deposits we use today would never have formed without water.

Cameron's research has led him to conclude that the parent liquids of the Sea of Tranquillity rocks had a limited compositional range. He believes the high titanium content of armalcolite and ilmenite resulted either from materials that were already rich in titanium or became enriched in the process of partial melting.

Cameron also concludes, with a touch of regret, that the Apollo 11 finding, particularly the lack of water, creates doubt that there is any chance of finding a wide variety of rocks and minerals on the moon.

"Of course," he adds, "we have to be cautious because we only have samples from one small place. Undoubtedly we have a lot to learn before we can know the full variety of rocks available."

Both Haskin and Cameron have done little more than preliminary research on the Apollo 12 rocks. Cameron suspects their titanium content is not nearly as high as that found in the Apollo 11 rocks; Haskin is unwilling to speculate at all on his early results.

Unlike the dramatic public announcements that flowed from the January Lunar Science Conference, results of the Apollo 12 studies will trickle from individual labs when each investigator chooses.

Funding for both projects was furnished by the National Aeronautics and Space Administration; Cameron's microprobe investigations were financed in part by the Wisconsin Alumni Research Foundation and by the National Science Foundation.

*(This article was first presented in* **UIR/Research Newsletter***)*

# could be the most important year of your life.

As you contemplate one of the most important decisions of your life, you will want to remember this: it is not just "a job" you are seeking—it should be the beginning of a career. And if it is to be successful, both you and your employer must need and want each other.

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# Man First? Man Last? The Paradox of Human Ecology

by HUGH H. ILTIS

The ubiquitous conservation speeches and environmental panels of today are dealing mainly with urgent problems of population, pollution, and crowding. That the priorities are given to these big-city, strictly human, homocentric syndromes is obvious and understandable. People die of pollution, people go crazy with crowding, people starve and lay waste the lands through overpopulation.

Hopefully, we may yet solve the *pollution crisis;* we can, I think, clean up our polluted nests. But if, in cleaning up the cities, we forsake the rest of life, if we, in our human preoccupation, let all but corn and cow slide into the abysmal finality of irreversible extinction, our species indeed will have committed ecological suicide.

However, there is no cause for optimism in the broader *environmental crisis,* for the specters of ecosystem collapse, of catastrophic extinctions of most living animal species and of a vast number of plant species, are on the horizon.

According to Talbot (*BioScience,* 15 March 1970), 3% of the world's mammals became extinct in historic times, not counting such prehistoric wonders as the Irish Elk or the Mammoth, and most of them during the past 50 years! Today, 10% to 12% can be considered endangered, extrapolating from the conservative 8% of species and subspecies listed as periled in the Red Data Book for Mammals of the International Union for the Conservation of Nature, and perhaps 130 of the 400 United States mammal taxa are believed to be threatened with extinction. Birds are faring no better! S. Dillon Ripley of the Smithsonian Institution recently estimated that a majority of animal species will be extinct by the year 2000! And Kenneth Boulding suggests that, with the present rate of human reproduction, in another generation it may be economically impossible to maintain any animals, except domesticated ones, outside of zoos.

Butterfly and wild flower, mountain lion and caribou, blue whale and pelican, coral reef and prairie land—who shall speak for you? My grandchild may need to know you, to see and smell you, to hear and feel you, to be alive—bright and happy!

Yet among all the many programs of the recent "Teach-ins" at the University of Michigan and at Northwestern University and 1000 other campuses, few spoke for the wild environment, for nature, for a *Morpho* butterfly in a Peruvian valley, for a timber wolf chasing caribou in Alaska.

This lack of concern is understandable, because man now occupies every bit of the earth and like a dictator, controls, or thinks he could control, if he wished, every living thing. As some see it, except for a few primitive tribes, "Man has . . . broken contact almost entirely with the ecological universe that existed before his culture developed. He no longer occupies ecological niches; he makes them."[1]

But have our genes ceased to need the environment that shaped them? If we destroy ecosystems and species with abandon—ecosystems to which we are adapted, species whose values we do not yet know, and cannot predict—we surely do it at our own peril.

Thus, the lack of focus on the natural environment, on the wild animals and plants, on the woods and streams, is frightening.

Who defends wilderness, the natural, unspoiled environment? Who defends the environment in which we evolved, and which we still need in all its purity? Who, except for a vociferous but ineffective minority?

The ultimate question one has to ask is this: Shall man come first, always first, at the expense of other life? And is this really first? In the short run, this may be expedient; in the long run, impossible.

Not until man places man second, or, to be more precise, not until man accepts his dependency on nature and puts himself in place as part of it, not until then does man put man first! *This is the great paradox of human ecology.* Not until man sees the light and submits gracefully and moderates the homocentric part of himself; not until man accepts the primacy of the beauty, diversity, and integrity of nature and limits his domination and his numbers, placing equally great value on the preservation of the environment and on his own life, is there hope that man will survive.

If we are to usher in an Age of Ecologic Reason, we must accept the certainty of a radical economic and political restructuring as well as ethical and cultural restructuring of society. No more expanding economics. No more expanding agricultures. No more expanding populations. No new unnecessary dams. No new superfluous industries. No new destructive subdivisions. We must stop and limit ourselves, now.

Let the archaic power structures of the technologically intoxicated cultures of the USA, USSR, Japan, and others, listen and listen well to the winds of change:

The earth and the web of life come first,
man comes second;
profits and "progress" come last.

Man now is responsible for every wolf, as well as for every child, for prairie and ocean as well as for every field.

Henceforth the laws to govern man must be the laws of ecology, not the laws of a self-destructive laissez-faire economics. And what the laws of ecology say is that we, we fancy apes, are forever related to, forever responsible for this clean air, for this green, flower-decked, and fragile earth.

Indeed, what ecology teaches us, what it implores us to learn, is that all things, living and dead, including man, are interrelated within the web of life. This must be the foundation of our new ethics.

If you love your children, if you wish them to be happy, love your earth with tender care and pass it on to them diverse and beautiful, so that they, 10,000 years hence, may live in a universe still diverse and beautiful, and find joy and wonder in being alive.

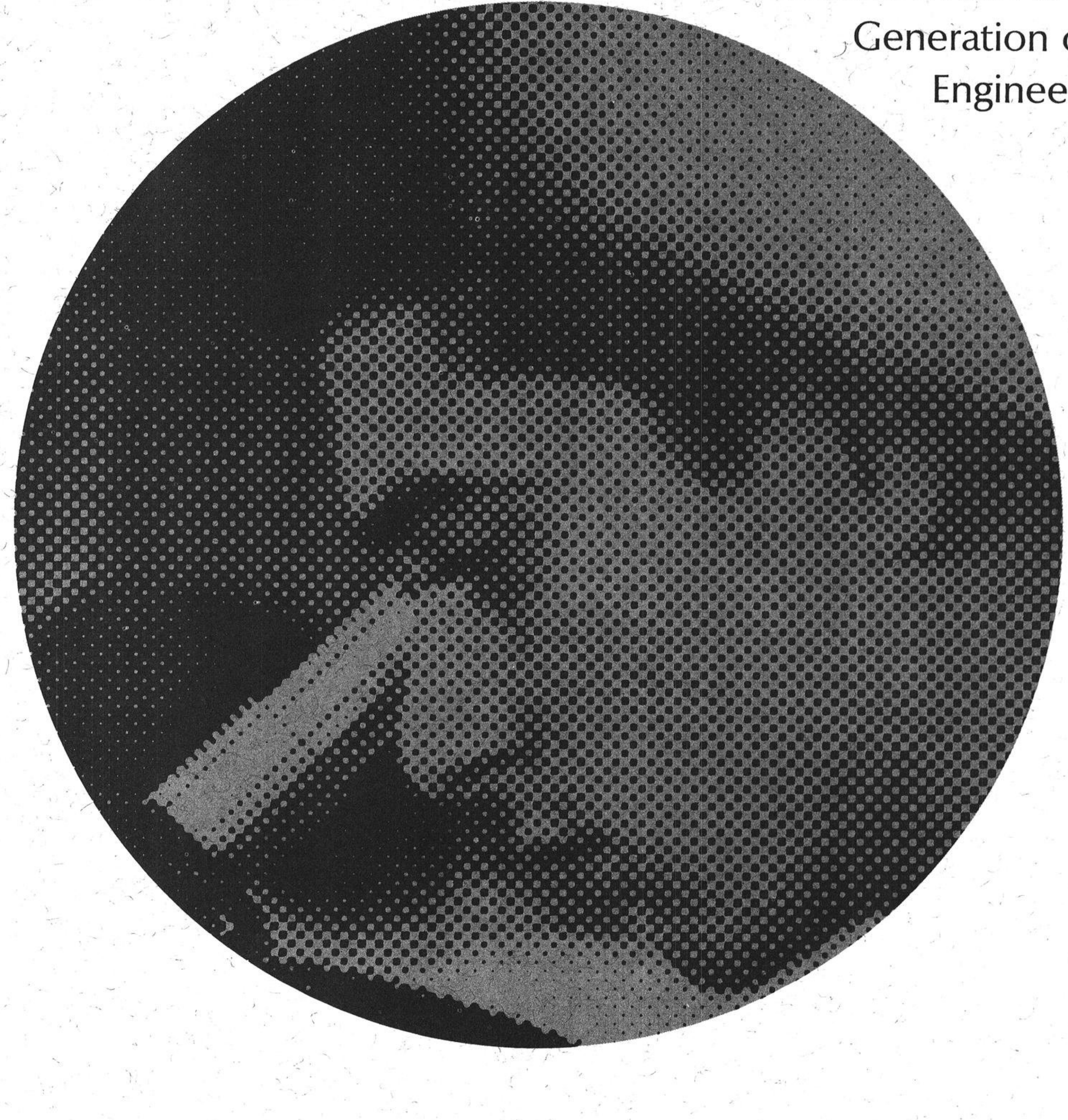
---

The author is with the botany department of the University of Wisconsin, Madison

[1] G. L. Stebbins, *Saturday Review,* March 1970.

# MAKING TOMORROW HAPPEN

## The Education And The Role Of The New Generation of Engineers



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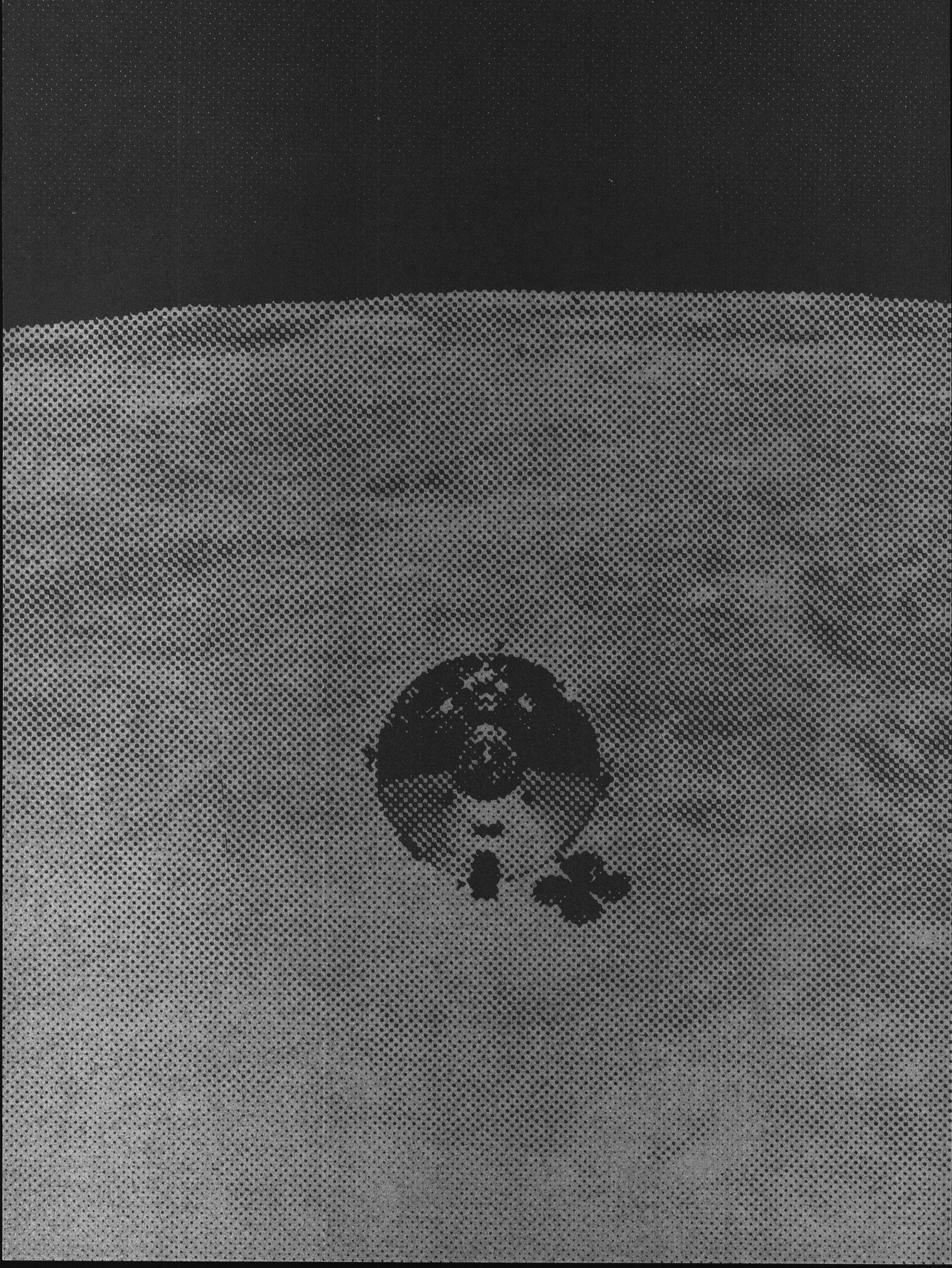

# MAKING TOMORROW HAPPEN

**As a species, man probably will survive.** According to some, such a statement is a gesture of optimism. There are those, qualified to be heard, who foresee a dead planet, killed not by thermonuclear war but by overpopulation . . . famine . . . thirst . . . fouled air.

A grim vision. And, because these things could so easily happen, a terrifying one.

Anyone who cares — and fortunately, so many do — knows also that if something does indeed ultimately destroy us, it will be because man chose to misuse technology instead of employing it wisely.

For engineers and scientists, this is profoundly troubling. As they look at the world around them, and at its problems and concerns, they aren't apt to offer simple solutions. But let's acknowledge with them that part of solving any problem, even any of these, is simply *identifying* the problem.

Let's agree on another point. If man's survival is being endangered by technology, then there's little doubt that his survival also turns on technology. Part of the solution to the ultimate problem, then, will obviously have to be technological. Equally obvious: the major job of solving that problem must thus be entrusted to men and women capable of dealing professionally with it — the men and women professionally known as engineers.

If this is so, and it's hard to believe otherwise, then a subtle and important change must take place in the ranks of American leadership.

Historically, the men who have shaped this country — the men who have directed it, governed it and handled its political, social and financial affairs — have been men who were trained as lawyers, businessmen, entrepreneurs; these leaders had seldom been trained as scientists or engineers. In fact, their insight into engineering was often much less than what engineers knew of the liberal arts, humanities, and social sciences.

Now, however, one can see far enough into the future — a disquieting, almost frightening future — to know that the kind of leadership we will need must include both engineers and scientists.

In terms of right now, of today, we can re-state the survival problem in quite another way: any young man or woman who decides to become an engineer can know that this career will lead not just to satisfying work but to a role in changing the world. Literally. By transforming technological knowledge into human renewal. By assuring survival.

This is a process that will require the work of two separate professions. The distinction between them often eludes the general public, but there is a difference between the "scientist" and the "engineer."

The scientist discovers principles and uncovers pure truth. But knowledge — known but not used — is, of course, of no value.

Engineers, however, are the professional users of knowledge — who take the scientists' principles and apply them to some purpose in imaginative and innovative ways.

Some engineers tell it a different way. They repeat a favorite expression of their friends who are aeronautical engineers: "Scientists learn what is — engineers create what never was."

Admittedly, and more and more in contemporary society, scientists and engineers work together and thus blur the distinction further.

Medical scientists wanted to help the human outlive his physical problems; from the brilliance of biomedical engineers and their fertile minds came such creations as the Pacemaker, to help human hearts.

Scientists discovered the truth about environmental problems; engineers will help solve those problems through innovative environmental engineering.

Scientists discovered the truths about the nature of animal fibers; engineers helped change animal, vegetable, and mineral elements to produce improved "man-made" fibers that require no pressing, that are dirt-resistant, water-resistant, and shock-resistant.

Still, the fact remains that when man set foot on the moon, that triumph was credited to scientists. It was, of course, theirs in part. But it was the engineers who were responsible for making the first moon shot *work*.

A man on the moon.

Earth day.

These two events, separated by so little time, sum up so well what man can achieve. And how he can fail.

## PAYING THE PRICE

Having credited the engineer for his triumphs, we can ask to what extent is the engineer at fault when technology fails? Probably less than his critics would claim; perhaps more than he may realize. The engineer, in his concentration on making miracles happen, assumed the public realized that such miracles are seldom beneficent to everyone. There's always a price to be paid. The engineer rarely makes the point, just as the public often forgets it.

Housewives, for instance, do indeed prefer "whiter than white" washes. Chemical engineers devised a way to give that to them. The price was phosphates. The proper amount is fine, but too much phosphate by too many housewives in too little water can result in a changed environment. The word becomes "pollution."

That's just one example from a list that could be endless. Further examples would also illustrate a basic fact of this or almost any other free society: we tend to make decisions

*Photograph Courtesy NASA*

**FINDING OUT MORE**—"My boy is 12. He wants to be an engineer. What should he do?"

"My daughter likes mathematics. She's very interested in science and engineering. Is that a future for a young woman?"

Questions like these are what launch future engineers on their careers in the profession.

There are local sources you can turn to:
☐ The nearest engineering college or school. ☐ The public or school library, and local chapters of engineering technical societies.

And there are regional and national sources that can advise you:
☐ The organization from which you received this report. ☐ The American Society for Engineering Education, 1 Dupont Circle, Washington, D.C. 20036. ☐ The Engineers' Council for Professional Development, 345 East 47th Street, New York City, New York 10017.

What kind of future? This report talks about the opportunities available to men—and women—engineering graduates.

How does a youngster find the opening that he or she wants?

The useful book, "Careers and Opportunities in Engineering," written by Phillip Pollack and revised by John D. Alden, makes the point succinctly: "Finding [a job] may not be a difficult task. The real problem is to discover a congenial position that will give you valuable experience, develop your potential as an engineer, and provide opportunities for advancement."

True enough; the authors go on to explain that the first years of most engineering jobs sometimes "are considered a professional apprenticeship," and may "involve a certain amount of drudgery in routine tasks. . . . You may as well face it at the start; you may have to begin at the bottom of the ladder."

However, as technicians and computers lighten others' burdens, the nature of any new graduate's first job changed. The beginner is apt to find circumstances not unlike those greeting his counterpart with, say, a degree in business administration, economics or political science. In engineering, the initial salaries may be higher. Brand-new engineers with a B.S. degree were being offered an average of better than $10,000 a year in 1970. Those with Masters' degrees could earn $11,000 to $12,000. A measure of experience in campus project work or work-study programs could mean still higher salaries. A Doctorate in engineering in today's job market is worth from $14,000 to $17,000 a year at the start. And salary figures have been rising steadily for more than a decade.

On these wages, a young person can live comfortably and begin to raise a family. For someone interested in security from the start, staff engineering jobs with major corporations also offer additional benefits—retirement plans and life and medical insurance. Furthermore, many employers, from oil companies through consulting engineering firms to government agencies, often help finance continuing and graduate education.

In an era when the body of knowledge sufficient for any professional is apt to change twice or three times during one lifetime, continuous learning is a crucial professional asset.

about innovations and improvements on the basis of the greatest good for the greatest number. A major bridge, for instance, can be built between points A and B, providing a transportation convenience to thousands of residents and commuters. However, the same bridge can take jobs away from five or six crews manning the old ferry boat. Should the bridge be built?

The answer is not only obvious, but it is part of a larger problem whose solution will be fully worked out by the coming generation of engineers—because, simply, they will *have* to work it out:

> By and large, engineers have been asked to solve a specific problem. Period. By and large, they have not been asked to measure the after-effects of their solution.

If the roster of problems and crises in the years ahead is to be dealt with successfully, changes are very much in order.

At one level, a necessary change will be enlightenment on the part of the state and federal government to seek the advice of engineers.

In their turn, engineers as a professional group are finding ways to voice their concern when their professional insight and experience can affect the quality of the nation's future.

And as individuals, engineers now see that they owe to themselves, their profession and their country a new thoughtfulness about the social implications of their achievements.

One of the spokesmen for engineering is the Engineers' Council for Professional Development. Its 1969-1970 President was Ernst Weber, holder of doctoral degrees in both engineering and philosophy. In a recent address on "Science and Societal Engineering," he noted that technological leadership was taken, only a short while ago, as the measure for the ranking of nations.

But, he noted, times have changed and now technology is "the scapegoat of society for all the ills that we cannot cope with." It's proverbial that

The chance to go back to school . . . to take specialized courses in a particular field . . . to work toward an advanced degree . . . is perhaps the key fringe benefit of many an engineering job today. With the proper background, a senior project engineer or group leader today can reach income levels of $30,000 or $40,000 a year.

As the engineer gains higher abilities, the openings for assistants to him in his work grow overwhelmingly. To permit the engineer to concentrate on his best efforts, the demand also grows for qualified personnel to fill equally-needed openings such as draftsmen, technicians and engineering aides. The range for such personnel has become enormous: there are both short-range and degree programs in such widely diverse technical areas as electronics, civil, industrial, architectural, chemical, etc. — discussed elsewhere in this report.

THE JOB MARKETPLACE — On the surface, the engineer is in a seller's market for his professional services, although specialized fields can become exceptions at any given time, including now.

Behind the encouraging facts is an intriguing story. For instance, the numbers of those entering engineering.

In 1956, engineering degrees earned by graduating college seniors represented 8.5 per cent of all baccalaureates awarded. By 1966, however, engineering graduates were only earning 6.8 per cent of the bachelors' degrees awarded. And by 1976, the trend will have reduced that percentage to 4.9 per cent.

This means that while the ranks of college graduates have, in general, been swelling, the number of graduate engineers has stayed level. In 1956, 35,800 engineers earned B.S. degrees; ten years later, that number was virtually unchanged.

We don't need to have an engineer's grasp of math to know what this means. It means that every year a decreasing percentage of young Americans consider engineering as a career.

Two other statistics pinpoint the enrollment situation further:

☐ Fewer than four hundred women received bachelor's degrees in engineering in 1969. ☐ Of the baccalaureates conferred in engineering during the 1969 school year, approximately 1 per cent went to black men and women.

Small wonder that virtually every engineering school in the U.S. warmly welcomes (and encourages) women, black and other minority students in their midst: for instance, 6,000 women are now enrolled in engineering.

Currently the number of graduating engineers is remaining static. And this is true in the face of an increased demand for them in the job market. According to U.S. Department of Commerce projections, 40,000 new engineering jobs per year will be opening up during the decade of the Seventies. On average, this means that every year there will be many thousands more jobs than there are new engineers to fill them.

All in all, present and projected figures can be troubling indeed to the profession. To students, however, these figures can't help but document an extraordinary career opportunity. In terms of a life's work, what can be nicer than going where you're wanted?

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people resent and even hate those to whom they become indebted.

The discoveries of science, he noted, stimulated innovative minds to create devices and machines. The discovery by Michael Faraday of the law of electromagnetic induction in 1831 laid the foundation for electrical machinery; Heinrich Hertz' demonstration of electromagnetic waves in 1887 opened the era of radio communications.

"The advent of farm machinery permitted mechanization of farm work, almost indispensable in the vast reaches of the West," he continued. In fact, "consistent mass production has brought all necessities and nearly all desirable household effects within reach of the average family."

But, he warned, "it is an axiom that the mere existence of man pollutes the environment. The combination of venture capital and the almost insatiable desires of society exploit technology; the decisions are essentially society's own responsibility."

The automobile, he said, is a classic example of this. The production of cars within the economic reach of very large numbers of American families justified real mass production. The public responded enthusiastically, giving rise to new industrial enterprises — and transforming the American landscape and our living habits to a remarkable degree.

"Let us remind ourselves," he noted, "that perhaps 10 percent of the working population are scientists and engineers, that at least 90 per cent of the working population have absolutely no knowledge, and in most instances no willingness, to know what the art and science of engineering really is." Without science and engineering, "their life indeed would be a miserable one and they would clamor for every bit of comfort even though there is a price attached to them."

He concluded that social and environmental solutions will come only through more science and technology, and not through restrictive action.

In the long run, thus, perhaps the

best hope for wiser use of technological power rests in the hands of young men and women now thinking about how, during their lifetimes, they will use their years of achievement.

If they decide on engineering, what might they contribute in the next twenty years? The probabilities could almost take that long to count. Here are a few:

☐ Use of lasers in dozens of ways ranging from brain-surgery to message transmission to tunnel building.

☐ Self-renewing fuel cells to power vehicles, or to light and heat houses for years.

☐ Three-dimensional, full-color picture-phone systems.

☐ Energy-generation by controlled photosynthesis.

☐ Packages made from organic components that, when disposed of, are waste-free in the recycling process.

☐ Nuclear power harnessed to de-salt sea water.

☐ Hydroponic farming — growing food in special solutions instead of soil — to increase food production for an increasingly populated world.

☐ Computers that improve health care by aiding in clinical tests, monitoring the patient and "memorizing" his health record.

☐ Restoration of beaches and coasts, stabilization of shore lines and complete exploration of the ocean bottoms.

☐ Development of reusable rocket boosters and nuclear power for deep-space vehicles.

Some of these processes have the gaudy excitement of new gadgetry. Others, however, are as much at one with nature as the water-wheel or the windmill. Which will catch our imaginations? And command our resources?

Are we to become so completely dependent on machine technology that we abandon natural beauty entirely in favor of totally-controlled environments? Or will we use new technological resources as an aid for men to enjoy the benefits of nature?

One way or the other, the next generation of engineers will be answering these questions. And in so doing, developing technologies undreamed-of today. More humane technologies.

## THE OPPORTUNITY AND DEMAND

Of all the professions (save one, teaching) engineering boasts the greatest numbers. More than one million persons are active in all branches of engineering. Job opportunities for engineers have risen more rapidly over the past decade than have opportunities for all other workers. Despite abrupt softenings and shifts in our never-predictable economy, there were 40 per cent more job openings for engineers in 1970 than there were in 1965.

This situation of over-demand and under-supply presents a philosophical irony. The very things that today's young men and women want the most — lasting changes in man's attitudes towards nature, more perceptive attitudes toward man himself — are precisely the things which engineers are educated for and equipped to deliver. The personal qualities that the young treasure most — honesty, directness, imagination, style, innovation, decision-making — are inherent in the engineering profession itself.

Perhaps the best way to see what engineering is (and can become) is simply to trace what has happened, and is now afoot, in the profession.

## A CATALOGUE OF WONDERS

Archeologists are constantly digging up new finds. One of the latest, described by Geoffrey Bibby in his recent book *Looking for Dilmun*, is a whole civilization that existed on the Red Sea shore of Arabia, apparently a link between the cultures of Northern Africa and of India. Its builders built no pyramids to house dead kings. Nor did they leave ziggurats like the Mesopotamians, man-made mountains which brought the priests of Assyria and Babylon closer to their sky-gods. This latest culture found by the archeologist's spade built its houses and palaces of humble brick, the baked-clay brick that is still a standard building material in the Middle East. But these primitive people built, and left as their real monument, something else: a system of canals and ditches for drainage and irrigation, in the heart of what is now a sand desert.

It was engineered.

Perhaps the first engineer was the human who discovered the principle of the wheel. And perhaps the first scientist was the one who discovered fire. In any case, we do know that every human culture from history consistently presents evidence of scientific knowledge and technological skill.

We tend to think of ancient engineering mostly in terms of bigness. Because they built pyramids and temples, still visible today, we see the Egyptians as the earliest engineers. Then came the Greeks and then the Romans. From the Romans on, engineers — the word probably evolved from the Latin for "ingenuity" — date their formal professional history.

The catalogue of early engineering wonders can be nearly endless. But note what some historians of engineering tend to omit — the lesser marvels and those of peoples long considered primitive.

Thor Heyerdahl taught us, for instance, that the outrigger vessels of the Polynesians were (and are) deliberately planned by generations of professionals — engineers, as it were, in marine design.

Other investigations reveal that those blue-stained, sun-worshipping Britons despised by Rome performed at least one engineering feat that stops the breath: Stonehenge, apparently constructed as an enormously sophisticated astronomical instrument. One could go listing other neglected masters of engineering, from the Saracens who built impregnable castles in the hills of the Holy Land to the Chinese Emperors whose Great Wall stretched for over 1,500 miles.

History tells us that all men, everywhere, from the beginning, have been builders and innovators.

The historical catalogue of man's achievements can also explain how modern engineering emerged in the Western culture. The evolution of engineering, from the later Middle Ages through the Renaissance and into the 18th century, was as a special profession with distinctive sub-disciplines. Such a study provides an understanding of the interrelationships and then the gradual separations into the first standard engineering specialities: military; civil; mechanical, etc. The Industrial Revolution made mechanical engineering, in particular, an even more specialized art — and also made the engineer himself "a professional," a person endowed with the knowledge, objectivity and integrity which set him apart.

But no historian, nor philosopher, can say exactly when early man made a crucial decision which has shaped engineering to this day — the decision that nature was a hostile fortress to be besieged and taken. Nature was an enemy to be overcome.

Perhaps that decision is implicit in all of human history since the beginning. Perhaps the odds, originally weighted so heavily in favor of nature and against man, have made us all see our lives in terms of a battle against natural forces.

But man has changed the odds. Because we now can manipulate our environment, we may well end up by destroying it.

But the liquidation of nature by man is not foreordained. Human cunning and contrivance can save as well as destroy. Already, this sense of knowledge as both a plowshare and sword has produced momentous changes in the way we train our specialists.

## THE EDUCATION OF AN ENGINEER

One definition of the professional, be he doctor, lawyer, architect or engineer, is that he possesses a body of special knowledge acquired by exacting, precise training. For hundreds of years most engineers could gain such training only as apprentices. Formal study of the sciences and mathematics underlying engineering knowledge was reserved for an elite.

The growth of engineering education — as opposed to training in craftsmanship — can be measured simply. In 1920, only 4,620 B.S. degrees in engineering were awarded, compared with 39,970 in 1969. This 50-year growth mirrors the hunger of a growing technological culture for the education which nourishes it.

However, such statistics only partially indicate what is happening. These count the students being graduated by institutions awarding the Bachelor of Science in engineering, usually after the standard four years of college education. But so intense is the need for talent in the spectrum of engineering education that other systems of education are growing up alongside the standard baccalureate programs.

At one end of the spectrum are junior - colleges, community - colleges and extension programs — in such technical training as computer programming, aero space, electronics, engineering draftmanship and dozens of others. These offer one, two or more years of training in specialty areas that demand trained technicians. The graduate can become an "engineering aide" and can receive an associate in engineering degree. In more than 2,000 communities, such programs are available; some 19,000 students were graduated last year.

At the other extreme, the truly professional engineer of the future probably will hold an advanced degree or advanced education. Some engineering colleges, for example, already have developed five-year and six-year programs of study leading beyond the B.S. in engineering directly to the Master's degree. In such developing interdisciplinary specialties as bio-engineering and systems engineering, graduate study is becoming particularly essential. Advanced degree programs are meeting the intensifying demands from industry and government. By making demands on engineering students comparable to those made on medical students (and by promising corresponding rewards), the programs requiring more than four undergraduate years reconcile the need for advanced education with the need for engineers who have capabilities not previously required. The most rapidly growing area of formal engineering education is the doctorate. As recently as 1957 only about 600 such degrees were granted. In 1969 the number was 3,378.

Between these extremes, new programs are developing which are referred to as four-year B.S. programs in technology.

Some 65 schools graduated 2,858 such students in 1968-69. Such graduates receive more technical instruction and/or management courses than the two-year engineering technician, and get a Bachelor's degree.

The educational spectrum is changing, is widening, is broadening. The demands for men and women are growing. The concept of engineering education includes more than technological knowledge.

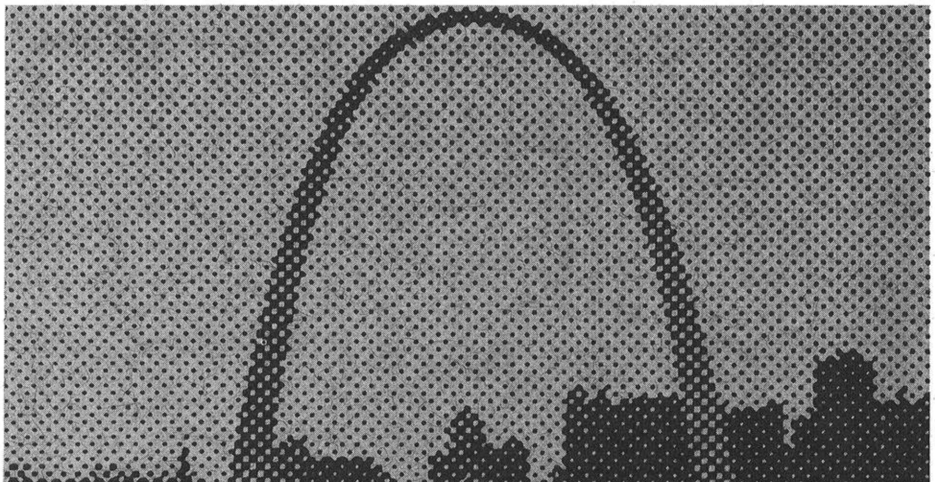
## THE HUMANITIES

A glance through the catalogues of almost any of the 269 engineering schools in the U.S. shows the shape of change. Or better yet, if we visit the campuses, attend the classes and talk with some of the students, we can pinpoint what's happening.

For instance, all accredited engineering institutions make it compulsory for engineers to devote approximately one-quarter of their studies to the humanities, the social sciences and the arts. Their graduates, now rising to distinction in business, government and academic work, do not apologize for this mix in their program. Rather, as one notable engineering college alumnus said: "We're giving the humanities its real emphasis. You can't be an engineer today without understanding the matrix in which engineering rests."

Thus, at all accredited engineering schools, the typical curriculum stresses an essential double involvement, in the specifics of engineering and in the broader themes of history, literature, philosophy, and the social sciences.

Such insistence might be only lip-service to the demands of culture-with-a-capital-C. But the indications are that courses in the humanities — long insisted upon by leading engineers who recognized their importance — suddenly are being recognized and insisted upon by the students themselves. The newly emerging graduate with an engineering degree is aware of the value of such courses to his major aim — engineering achievements.



## THE SCIENCES

Part of this same new maturity in engineering education is a shift in attitude toward the sciences. On one level, this new approach is a confusion of realms. The old distinctions between scientist and engineer (and the old myths about both) are being eradicated. Traditions sometimes die hard.

But today the teaching of science to engineers is burying forever the myth of the engineer simply adapting other men's discoveries to material ends. Early in their college career, engineering students take courses — in mathematics and physics, for example — which would have dismayed the physicists and mathematicians of a generation ago. That youngsters in their late teens can absorb today's material testifies to the dramatic changes in the teaching of mathematics and science in the secondary schools.

More to the point, now engineering students receive intensive instruction in science so that they can grasp more firmly the theoretical implications of their profession.

Because every school of engineering has its own view of how to educate its students, generalizations are difficult. But technological change is one reason why virtually every engineering school offers scores of "interdisciplinary" courses — and why the whole engineering curriculum is being divided and subdivided. For instance, the Engineers Council for Professional Development now accredits 67 different curricula, including such new ones as environmental engineering and management engineering.

At the same time, the demands of the sciences on engineering are forming new links and breeding new hybrid disciplines. To the current generation of students, the interdependence of science and engineering must be recognized as a basic fact of professional life. For example, biochemical engineers are experimenting with ways of using colonies of bacteria to generate electric power. And transportation engineers are trying to plan ways to move individuals from their homes via commuter corridors directly to their offices five, ten, thirty miles away.

The implosion in engineering is also the product of an even more profound phenomenon: a basic change in the philosophy of engineering.

Increasingly, young engineers and engineering curricula see the job of the engineer as one of harmonizing man's needs with nature, of accommodating human technology with natural forces and resources.

In effect, the engineer is also becoming an ecologist.

## THE CAREER OF AN ENGINEER

Just as an engineer's professional education must continue after he graduates, so his career can begin before his schooling is completed.

Most engineering schools, in addition to educating future engineers, serve as centers of research and as project centers for industry and government. By working with faculty members and others on such projects, the qualified student interested in a particular specialty can involve himself in its practicalities while he's still in school. Similarly, the cooperative engineering education programs and work-study programs sponsored by business firms offer students practical experience and money in return for their months of on-the-job work each year; the same is true regarding summer employment.

In part, the abundance of opportunity available to the student reflects the shortage of specific types of engineers. In part, also, it mirrors the eagerness of potential employers to single out promising prospects for future permanent employment and to give them seasoning. Instead of reflecting the bad old days when an engineer was educated by simple apprenticeship to a practitioner, the varieties of opportunities — either on or off the campus — are evidence of the fact that the education of the engineer is a combination of the best efforts of both the engineering schools and industry.

## AFTER GRADUATION . . .

Some of the same elements which lure people into engineering — elements like curiosity and adventure — lead away from the routine and gradual progress of the everyday job. They lead instead to special opportunities. To bridge-building in under-developed nations for the civil engineer. Or to the projects like utilities designs for environmentally-controlled cities, still on the drawing boards. Or to ways to restore once-swimmable seashore areas to pollution-free beaches again. Or to perfect pollution-free autos.

Let's look a little more carefully at these two kinds of opportunities, and do so through the eyes of a young engineering graduate who feels strongly that he wants a career of achievement, of accomplishment.

If he considers the field of corporations, large or small, he will quickly find that during the past decade they have increasingly come to understand this need of engineers for achievement — and indeed of their own firms. Evidence of this abounds in the recruiting advertising which these corporations direct at young engineers:

"To solve America's man-size traffic jams, our firm needs man-sized hands."

"When it comes to projects, we don't talk about fads, frills and fancy stuff. We just name our current projects. See if they don't measure up to what you're really looking for."

"Want technological growing room? Furnishing elbow room for new ideas is an old story at our corporation."

"In the next few years, our engineers and scientists will be working on new ideas and products to improve man's diet, housing, clothing and shoes; reduce the toll of viral diseases; make light without heat; enhance X-ray diagnosis; control insect plagues; repair human hearts or kidneys; turn oceans into drinking water . . . and anything else *you* might think of."

Each of these messages is sincere in defining the need for young engineers. Each advertiser is indeed looking for the young creative mind that will develop solutions, not further problems.

But perhaps our hypothetical job-hunter has a strong sense of independence and it prompts him to strike out for himself as a consultant in his own particular specialty.

Most consulting engineers (like most consultants in other fields) begin as some firm's employee. When they have amassed the type of specialized professional knowledge for which clients want to pay, realistic engineers then often hang up their own shingles. Not every man needs to strike out on his own. So vast and complex is our technology that new discoveries and large-scale applications are most frequently the products of teamwork.

To succeed as a soloist in engineering has become increasingly difficult in other than specialized areas. More often, a team of engineers sees the potential in some new development and — as a group of three or four men — gathers enough money to form a small company and give the new idea a try. To be sure, few such efforts grow and prosper at least to the extent that they become giant corporations.

But some do. Take for instance Texas Instruments. Once it was a tiny venture, run out of a garage. Its size today can be measured by FORTUNE's list of the 500 largest industrial corporations in the U.S. (ranked by sales). On the 1970 FORTUNE list, Texas Instruments stands as 135th.

Or, for that matter, drive along Boston's famed Route 128, where in recent years dozens of companies begun by engineers have located themselves. In a nation supposedly dominated by a few giant corporations, technological entrepreneuring has paid engineers virtually in diamonds.

The engineer, moreover, is perhaps one citizen for whom such entrepreneurship holds the fewest risks. A planner by training, the engineer can see around corners that the salesman, for instance, may not know are there.

Most importantly, an engineer's skills are locked in his brain, and implicit in his profession is an understanding of change. If he understands, too, that he himself must broaden his scope (and learn the vocabulary of business management as well as that of his specialty), his independence or his membership in a firm can be well rewarded.

## OPPORTUNITIES FOR SERVICE

Perhaps the worst mistake a young engineering graduate can make is to assume that private businesses — whether they're the big corporations or the consultants in his specialty — are uninterested in the changing responsibilities of the engineer.

Nothing, literally, could be farther from the truth. When Henry Ford II can insist in public that "the first priority of (the Ford Motor Company) during the 1970's will be our environment," laymen and engineers should take note. Concern with man and his environment has bitten deep into the corporate conscience. According to a recent FORTUNE survey, six out of ten chief executives of the country's largest corporations feel that "environment is a problem of the highest priority." Most expect to make huge commitments of talent and capital to help solve such problems.

"From here out," a rubber-industry executive has said, "we are going to divert increased productivity to improving the quality of life rather than the quantity of possessions."

This massive shift in priorities means that the engineer in business can be working as hard on survival issues as the academician or the engineer in government service, or as the most concerned official of the Audubon Society or the Sierra Club.

In truth, nobody today can know what will be the impact of a ripening technology on the quality of life. We're so used to the slag-heaps, polluted air and human waste of an industrial civilization that we cannot imagine them gone.

But 20 years ago, the miniaturization of electrical circuits had only begun . . . computers were still monsters made of big vacuum tubes . . . more people travelled by train than by airplane . . . and it still took 14 hours to fly from New York to London.

The difference between what was and what is — that, too, is the engineer's job.

## WHO SHOULD BE AN ENGINEER?

For all its brevity, this question challenges some deeply-held convictions. Many engineers believe that their special calling appeals only to those with recognizable "aptitudes" for the tools of the engineer — the physical sciences and mathematics. And disturbingly, many high school students feel that they lack the aptitudes. Or that somehow a flair for poetry or music or foreign languages or art is incompatible with a sensitivity to numbers and the properties of the physical world.

Another fact that often goes unnoticed is that an engineering degree has long proved it can open doors on successful careers in a wide variety of

Photograph by Walter Holt for Swarthmore College

occupations—from accounting to medicine. For the young student who feels he "can do anything" and for the student who doesn't know what he *does* want to become, it's worth noting that today most graduate management-business classes are made up of a large percentage of engineers, just as many engineers are now becoming medical doctors. Looking at the employment market, it seems no exaggeration to say that an engineering education will be to the 70's what a liberal arts education was to the 50's. FORTUNE, in fact, has predicted that by 1980, 75% of corporate officers in the U.S. will come from engineering backgrounds.

Misconceptions about engineering are unfortunate; its advantages have remained undetected for too long. On the one hand, engineering needs more—and more gifted—students, as every profession does. Indeed, engineering especially needs those who can see in the profession a means to wider ends, not merely an end in itself.

On the other hand, thousands of students thrive on the intellectual discipline and decision-making which engineering training enforces.

The gap between the profession itself and these potential engineers is beginning to narrow. The drastic changes in our educational system required to close this gap are under way. In our elementary schools, children are learning that numbers are beautiful as well as useful. And that the sciences are not to be found only in textbooks about famous men . . . or in experiments that merely repeat results already known. Rather these reflect a special way of looking at the world. Given time, this learning will turn every school boy and girl into knowing citizens.

The job of explaining engineering to students and the public is a job for engineers themselves. Knowing that time is short, many engineers already are narrowing the gap in understanding between their calling and the layman. Working through their professional associations and their employers, they have embarked on a wide variety of projects. Some current ones include:

☐ sponsoring local surveys on the environment and conservation;

☐ setting up speakers' bureaus to arrange talks in local elementary, junior high and senior high schools;

☐ working with educators to introduce courses that help high school students to understand the concepts behind technologies surrounding them today;

☐ developing exhibits of current and future technological trends for display in local libraries and circulation to the schools;

☐ establishing adult-education courses for non-engineers, focusing on the "new math," basic mechanics and physics;

☐ lending technical assistance to artists and musicians on projects involving color, light and sound manipulation. (Most notable is the group called Experiments in Art and Technology, involving both artists and engineers, individually and with corporate financing. For example, part of an American pavilion's exhibit at Osaka's EXPO '70 resulted from the combined creative efforts of EAT, engineering students and a major corporation.)

The purpose of such programs is simple: to create, within a local community, a real understanding of the significance of engineering, and its closeness to the concerns of those untrained in its skills.

Above all, such programs arouse people to ask questions about engineers and engineering. To consider engineering know-how as the vital resource it is. To look to tomorrow with a sense of constructive urgency. Because, to an extraordinary degree, the people who will make that tomorrow happen will be engineers.

**MAKING TOMORROW HAPPEN is a project of the Engineers' Public Information Council, a national association of professionals associated with engineering who seek to increase public understanding of technology and its implications.**

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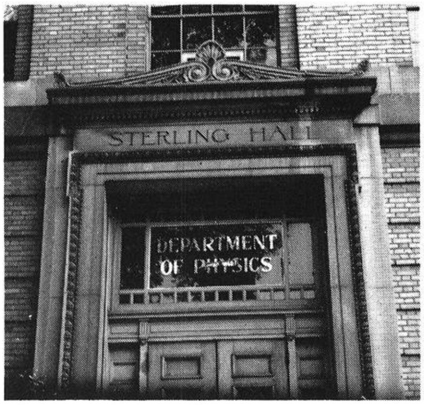
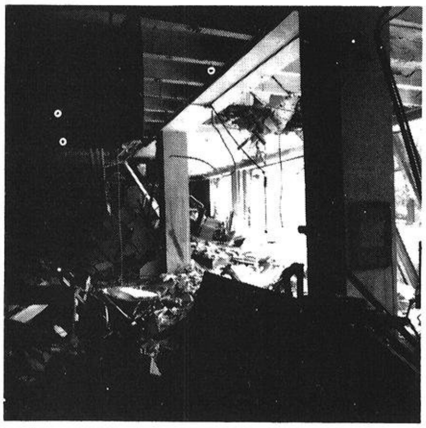
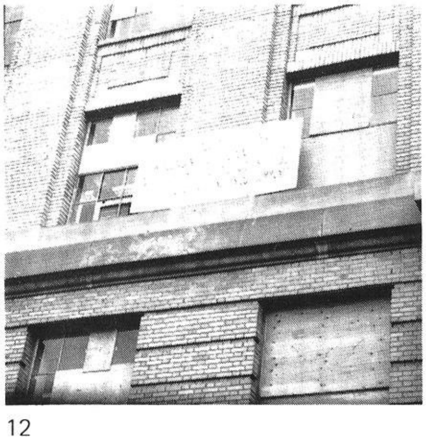
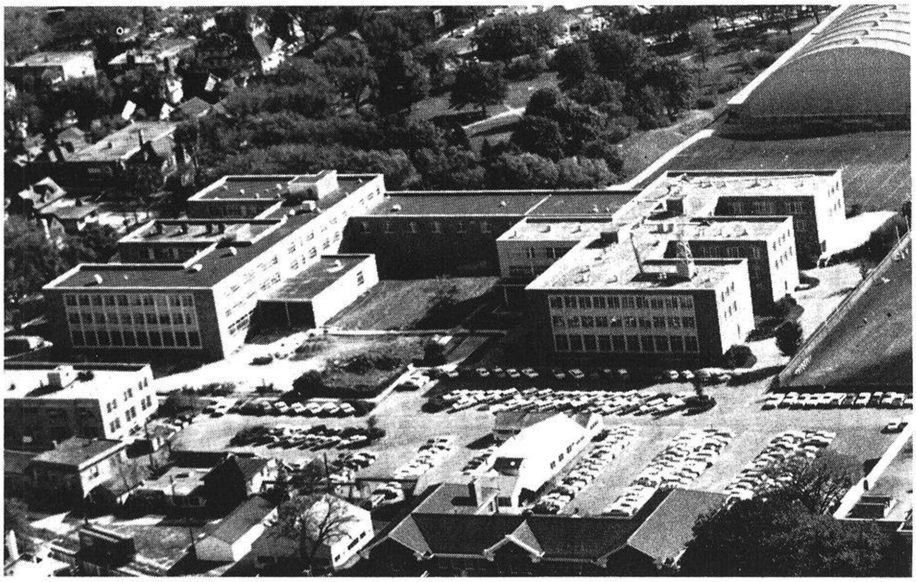
# U. W. Campus

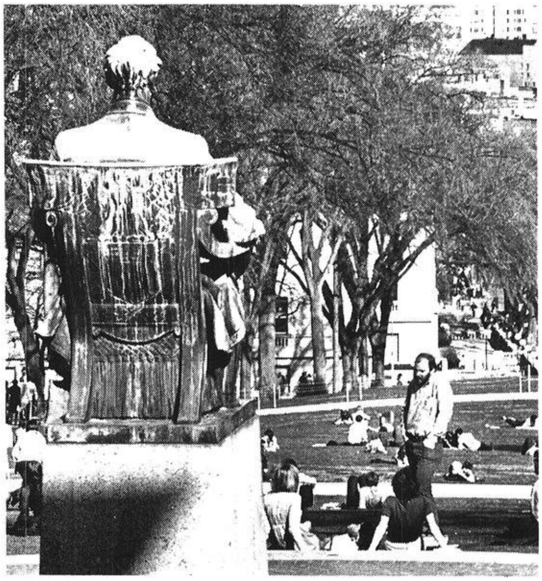
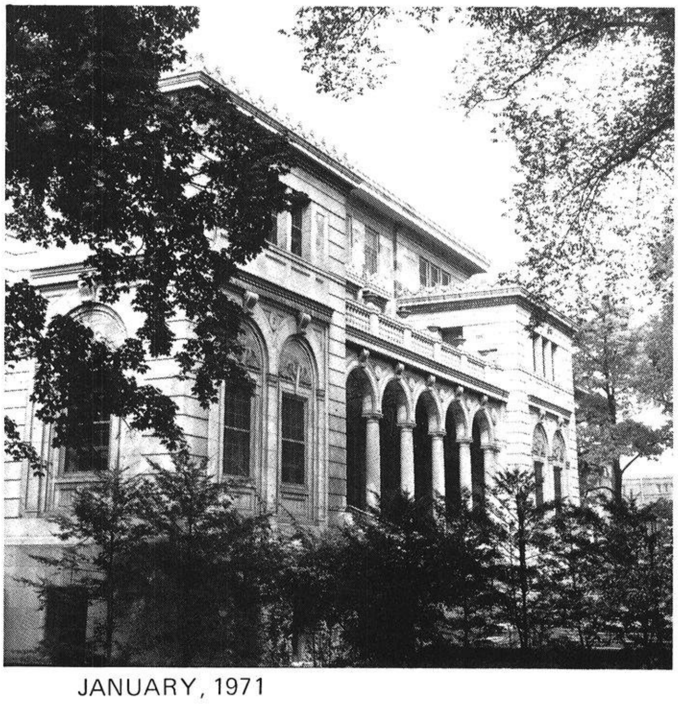
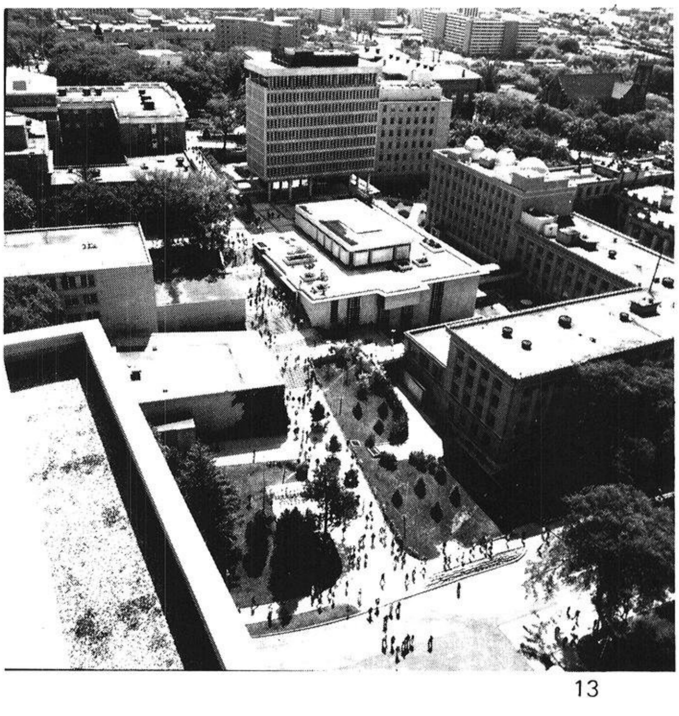










# What's in a Name?

*Have you ever wondered what to put on an interview form or application blank under the heading "type of work desired?" Professor James A. Marks, placement director, has compiled the following job title dictionary and has distributed it to both students and interviewers in order to improve understanding regarding job interests, but the Wisconsin Engineer feels that it may also be a helpful reference in planning your career.*

| | |
|---|---|
| **Design Engineering** | The engineer in design prepares plans and specifications for new products or redesigns existing products to make improvements. He selects materials and components and may recommend manufacturing processes. Design may also include the fabrication and testing of design concepts and models. Specifications, product cost and engineering objectives must always be kept in mind. |
| **Development** | Development engineers are responsible for developing new products and finding new uses for established products to meet the needs of industry or of the individual consumer. They concentrate on problems such as planning, designing, and testing products to match performance requirements. They also seek to effect product improvement for increased performance efficiency, higher quality, and lower manufacturing costs. |
| **Production Supervision** | The production supervisor is responsible for producing a product in desired quantity and quality and for the safe performance of the men and equipment in the operating unit assigned to him. Responsible for:<br>(1) Instructing others in proper operating procedures, then following up to assure compliance.<br>(2) Planning production and maintenance schedules.<br>(3) Assisting in resolving labor problems.<br>(4) Initiating process-improvement programs to reduce costs. |
| **Research** | Obtain new scientific knowledge of physical and human phenomena. Applied research would be doing much the same thing in areas impinging upon technologies of interest to the company. Other aspects of research might include:<br>(a) Investigate new fields and discover new products<br>(b) Provide new uses for products<br>(c) Improve existing products and processes |
| **Sales Engineering** | The sales engineer acts as a liaison between sales and engineering and is responsible for customer contact and technical specification analysis. This includes preparing quotations and initiating and recommending engineering design changes. He may also advise on application problems, handle correspondence on product quality, toxicity, and visit customers with salesmen on serious problems, and prepare evaluation reports on experimental products with key accounts. |
| **Field Service Engineering** | The field service engineer usually is in close contact with the customer. His duties often include supervising installation and instructing customer personnel in the operation and maintenance of the product. |
| **Technical Services** | Providing maintenance and repair of consumer, commercial and industrial products and systems at service centers and at customer sites. |

*(continued next page)*

| | |
|---|---|
| **Facilities Control Engineering** | The Facilities Control Engineer has primary responsibility for the planning and incorporation of new equipment and facilities, the replacement of worn or obsolete facilities, and the maintenance of equipment. He prepares cost reduction and quality improvement studies. He also performs economic analysis studies—comparing models of equipment or alternate methods of operation. A Facilities Control Engineer is typically required to plan new equipment or facilities to increase existing production or to produce a new product. |
| **Test Process Engineering** | The Test Process Engineer is responsible for providing the test equipment and test procedures that will assure meeting production and manufacturing schedules. He determines the most efficient and economical methods of performing calibrations and test operations for sub-assemblies and/or completed equipment, plans and writes test specifications and processes, and determines test equipment required. |
| **Controls Engineering** | The Control Engineer, usually an electrical engineer, designs and develops systems which control a large variety of machines, processing lines and material handling operations. Working with relays, transistors, silicon controlled rectifiers and accessory items; implemented by a knowledge of machine characteristics, digital logic, systems analysis and manufacturing techniques, the engineer solves the many, varied control problems encountered in industry. |
| **Plant Engineering** | Planning, developing, installing, and maintaining the plant facilities and services required by the company are the responsibilities of the Plant Engineer. Duties could be layout of machines and equipment, layout of new or existing plants, provide heavier electrical systems, expand or remodel production lines, increase compressed air services, provide air conditioning and humidity control, install larger boilers and all of the other engineered services required in a modern industrial plant. |
| **Quality Control Engineering** | The Quality Control Engineer is responsible for the quality and reliability of the product. He controls and evaluates all manufacturing materials and operations which affect product quality and reliability. His specific duties:<br>(a) Develop and perform incoming, in-process, and final inspection procedures.<br>(b) Provide facilities for calibrating instruments, equipment, and tooling.<br>(c) Develop quality assurance procedures that ensure that maintenance of reliability is inherent in the design.<br>(d) Develop methods of measurement and sampling size from which to provide design engineering with statistical guidance.<br>(e) Perform quality acceptance evaluations.<br>(f) Evaluate module and component reliability needs and status. |
| **Process Engineering** | Responsible for designing new plants, making changes in existing plants, and engineering new processes. Maybe trouble shooting an existing process and locating its bottlenecks, in order to increase production capacity, to improve product quality, and to lower operating costs. Or, you may be assigned to develop a new process, adapting it to industrial equipment in a pilot plant. |
| **Development Engineering** | A development engineer initiates design changes in existing products; modifies existing products; prepares engineering specifications to keep production within cost limits. |
| | It is the function of the production engineer to create maximum value from given inputs. His assignments include increasing production capacity, debottlenecking, and improving overall efficiency. He is involved in reworking existing units or designing new units to produce a new product, installing and starting up new equipment, and making improvements in procedures of materials handling and quality control. |
| **Product Engineering** | Product Engineering designs for production and solves problems of manufacturing operations, engineering changes, costs, and servicing. Responsibility continues throughout the manufacturing of a product and includes the handling of engineering changes. |
| **Product Test Engineering** | Product Test Engineering initiates the analysis of new product capabilities. Engineers in this area follow a product from early design concepts through |

| | |
|---|---|
| | the first manufactured units, devising test procedures in advance, and originating methods that will predict product capabilities accurately. |
| **Materials Engineering** | Advise design and development engineers on the availability of materials. Evaluate materials and process developments for product line and design groups. |
| | Prepare specifications on non-standard equipment, initiating the purchase of components and the development of special devices to meet customer requirements.Assist and advise design engineers in the development of equipment. Direct technicians and drafting personnel in the development of customized instrumentation and control systems. Coordinate all phases of an assigned project with the customer and with the project team. |
| **Programmer** | Functions: Develop and maintain advanced programming systems which enhance and extend the usefulness of computer systems. Analyze software and evaluate customer's programming requirements. Provide liaison between marketing and engineering teams. |
| **Systems Engineer (Data Processing)** | Functions: Analyze the requirements of science, industry and the government in all areas of data processing, including communications, information storage and retrieval, random access, command and control, process control and real-time systems. Evaluate alternative systems to meet these requirements in both hardware and software. Design tests and diagnostic procedures to verify performance of prototype equipment according to specifications. |
| **Reliability Engineering** | Conduct component and system reliability studies in order to determine product effectiveness. Analyze test results and make recommendations for changes to insure compliance with customer specifications. |
| **Systems Engineering** | Position: Systems engineer will be trained to interpret, evaluate, and comply with customer specifications. He coordinates efforts of the various engineering disciplines (electrical, mechanical, maintainability, reliability); also procurement, production, and manufacturing engineering efforts. Customer and sub-contractor engineering liaison is also his responsibility. He schedules engineering manpower and end item design and testing to assure that the product is properly designed, tested and delivered to the customer on time. Specifications for sub-contract items are generated by the systems engineer, and he furnishes other engineering data to procurement to aid in the purchase of these items. In summary, the systems engineer obtains, analyzes and evaluates technical data to fulfill requirements of both the customer and his company's own engineering and production facilities. |
| **Value Engineering** | Position: Value engineering has staff responsibility for reinforcing operating divisions, with the objective of improving product quality while reducing cost. The engineer's duties will involve planning, execution and evaluation of cost improvement projects covering all phases from product inception through design, development, testing, equipment design, tooling, and production. |
| **Production Control Engineering** | The Production Control Engineer is responsible for designing new control systems, the installation of these systems, and the improvement of scheduling systems which coordinate production efforts. |
| **Project Engineering** | The Project Engineer designs equipment, supervises its installation and handles initial operation. Development of new processes and equipment to reduce cost and improve quality, equipment and methods to promote use and sale and to provide technical assistance to plants and customers as requested. |
| **Manufacturing Engineering** | Manufacturing engineers develop new standards, study manufacturing processes for methods of improvement, prepare cost estimates for new product proposals and develop new concepts for automating machinery and equipment. Closely related to Production Engineering. |
| **Maunfacturing Methods Engineering** | The Manufacturing Methods Engineer determines the necessary equipment, tools and instructions for production of an equipment in accordance with drawings and specifications from Design Engineering. His responsibility extends:<br>(a) from the time a product has been designed and released for production<br>(b) through the design, set-up, and initial operation of the production line |

| | |
|---|---|
| | (c) until the units are complete and ready for testing, and<br>(d) the operating production line is turned over to Line Supervision.<br>General duties: Prepares plans for the application of automated data processing equipment to the solution of company data recording, reporting and operational and administrative problems, and follows development of the plans to satisfactory application. |
| **Systems Design and Development Engineering** | Systems Design and Development helps to create new computer systems, with development engineering, product engineering, and programming teams working together to plan and develop an entire system, construct a working model, test it and help put it into production. |
| **Circuit Design (Data Processing)** | Functions: Design high-speed linear and switching circuits for use in central processor and input-output equipment. Develop advanced memory techniques including thin films, large-scale partial switching, linear-select core memories and coincident-current core memories. Develop microminiaturization techniques. Develop power systems for power supply design, cable design, start-up switches and interlocks. |
| **Electro-Mechanical Engineer (Data Processing)** | Functions: Design mechanical components for input-output equipment, including high-speed mechanisms operating in milliseconds, repeatable in microseconds and with operating life in the hundreds of millions of cycles. This equipment performs the functions of printing, feeding, indexing, selecting, sensing and punching. Analyze performance and reliability requirements while stressing simplicity, serviceability and cost. Develop techniques and equipment to test and evaluate prototype models. Evaluate developments in metallurgy, kinematics, fluid dynamics, physics, magnetics and optics affecting the state-of-the-art of electronic data processing mechanical components. Determine the optimum method for packaging circuitry by evaluating materials, component cooling, and vibration and structural considerations. |

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# Hallowed Halls of Ivy Enclose Unique Educational Experiences

STUDENT ENGINEERS –

Do you know of any one course that offers:

1. Interdiciplinary involvement
2. Social contact
3. Parliamentary procedure and legal reasoning
4. Money management
5. Personnel management
6. Public relations
7. Opportunities for job training
8. Post graduate (also summer) job placement

AND ONLY REQUIRE ONE EXAM?

*The Cost? – Nothing above what you already pay.*
*The Credit? – Infinite.*
*What is it? – A fraternity. Now you know the name, go back through the list. If you don't believe it, you better come and see it!*
*When? – February 14 and 15.*
*Where? – Watch for further announcements.*

*P.S. – That one exam is the one you take after you graduate. The exam is called* **LIFE** *and you will pass it with a perfect mark.*

# Puzzle Answers

1. The next two numbers in the progression . . . 61, 52, 63, 94 . . . are 46 and 18. This one was a little tricky. The whole progression results from the integers 4, 5, 6, . . . squared, and then reversed digitally.

$4^2 = 16 \ldots 61,\ 5^2 = 25 \ldots 52$, etc.

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2. 1111111111. Yes, each number equals 10 but written in different bases: $10_{10} = 10$; $10_9 = 1$; $10^2 = 2020$. How about that!

* * * * * * * *

3.

| Step | 10 gal. | 7 gal. | 3 gal. |
|---|---|---|---|
| I | 10 | 0 | 0 |
| II | 3 | 7 | 0 |
| III | 3 | 4 | 3 |
| IV | 6 | 4 | 0 |
| V | 6 | 1 | 3 |
| VI | 9 | 1 | 0 |
| VII | 9 | 0 | 1 |
| VIII | 2 | 7 | 1 |
| IX | 2 | 5 | 3 |
| X | 5 | 5 | 0 |

* * * * * * * *

4.

$$\mathrm{III} \equiv \frac{\mathrm{XXI}}{\mathrm{VII}}$$

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5. Try [2, 11, 5, 10]. Is this right? [-2, -1, 1, 2]?

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6. Rope – 5 feet; Monkey – 1½; Uncle – 2½.

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7. When the four flies meet at the center they have each walked a distance equal to a side of the square.

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8. a. $10\pi$

b. The total surface area of the figure is 302.75 square inches. The formula for computing this area is: $A = \pi r \sqrt{r^2 + h^2} + \pi r^2 + 12.57R^2\,(1/1\text{-}K^2)$, where r is the radius of the cone's base, h is the height of the cone, R is the radius of the largest inscribed circle, and K is the Proportiounality constant of the inscribed circles' radii (for this problem the value is .46).

c. The percentage of the icosceles triangle covered by the insribed circles is 73.25. Note: The area of the circles is approximately 29.3 square inches. The formula $A = \pi r^2(1/1K^2)$ is used for this computation with the symbols having the same meaning as in part b.

# Teaching in Perspective

*Reprinted with Special
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CHEMICAL ENGINEERING
Magazine*

Some time ago, I received a call from a colleague who asked if I would be the referee on the grading of an examination question. He was about to give a student a zero for his answer to a physics question, while the student claimed he should receive a perfect score and would be if the system were not set up against the student. The instructor and the student agreed to an impartial arbiter, and I was selected.

I went to my colleague's office and read the examination question: "Show how it is possible to determine the height of a tall buillding with the aid of a barometer."

The student had answered: "Take the barometer to the top of the building, attach a long rope to it, lower the barometer to the street, and then bring it up, measuring the length of rope. The length of the rope is the height of the building."

I pointed out that the student really had a strong case for full credit since he had answered the question completely and correctly. On the other hand, if full credit were given, it could well contribute to a high grade for the student in his physics course. A high grade is supposed to certify competence in physics, but the answer did not confirm this. I suggested that the student have another try at answering the question. I was not surprised that my colleague agreed, but I was somewhat surprised that the student did.

I gave the student six minutes to answer the question, with the warning this his answer should show some physics. At the end of five minutes, he had not written anything. I asked if he wished to give up, but he said no. He had many answers to this problem; he was just thinking of the best one. I excused myself for interrupting him and asked him to please go on. In the next minute, he dashed off his answer, which read:

"Take the barometer to the top of the building and lean over the edge of the roof. Drop the barometer, timing its fall with a stopwatch. Then using the formula $S = \frac{1}{2} gt^2$, calculate the height of the building."

At this point, I asked my colleague if he would give up. He conceded, and gave the student almost full credit.

In leaving my colleague's office, I recalled that the student had said he had other answers to the problem, so I asked him what they were. "Oh, yes," said the student, "There are many ways of getting the height of a tall building with the aid of a barometer. For example, you could take the barometer out on a sunny day and measure the height of the barometer, the length of its shadow, and the length of the shadow of the building, and by the use of simple proportion, determine the height of the building."

"Fine," I said, "and what are the others?"

"Yes," said the student. "There is a very basic measurement method that you will like. In this method, you take the barometer and begin to walk up the stairs. As you climb the stairs, you mark off the length of the barometer along the wall. You then count the number of marks, and this will give you the height of the building in barometer units. A very direct method.

"Of course, if you want a more sophisticated method, you can tie the barometer to the end of a string, swing it as a pendulum, and determine the value of "g" at the street level and at the top of the building. From the difference between the two values of "g", the height of the building can, in principle, be calculated.

"Finally," he concluded, "there are many other ways of solving the problem. Probably the best," he said, "is to take the barometer to the basement and knock on the superintendent's door. When the superintendent answers, you speak to him as follows: 'Mr. Superintendent, here I have a fine barometer. If you will tell me the height of this building, I will give you this barometer.' "

At this point, I asked the student if he really did not know the conventional answer to this question. He admitted that he did, but said that he was fed up with high school and college instructors trying to teach him how to think, to use the "scientific method," and to explore the deep inner logic of the subject in a pedantic way, as is often done in the new mathematics, rather than teaching him the structure of the subject. With this in mind, he decided to revive scholasticism as an academic lark to challenge the Sputnik-panicked classrooms of America.

# Right On

Two engineers each had a horse, but they couldn't decide which one belonged to whom. They cut the mane off one horse so they could recognize him, but it soon grew back. They they cut the tail off the other one, but it too grew back. Finally they measured the horses and found that the black one was four inches taller than the white one.

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And then there was the Indian who was so fond if iced tea that he drank twenty gallons. The next day they found him dead in his teepee.

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Then there was the M.E. who thought that steel wool was the fleece from a hydraulic ram.

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Famous last words: "Hell, he won't ask us that."

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CLASSIFIED AD –

Young man transferring from Engineering to Arts & Sciences would like to trade one good study lamp for comfortable mattress.

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A doctor, an engineer and a lawyer were talking.

"My profession is the greatest," said the doctor, "because Jehovah took a rib out of Adam to give to Eve and that was the first operation."

The engineer said his profession was the greatest since he had made order out of chaos.

But the lawyer replied: "Aha, but who made the chaos?"

How High, Spiro?

Example problem from a Graduate Exam: A cross-eyed woodpecker with a cork leg and a synthetic rubber bill required four and one-half hours to peck three-fourths the distance through a cypress log 53 years old. Shingles cost 79 cents per hundred and weigh eight ounces each.

The log being pecked upon is 34 feet long and weighs 46 pounds per foot. Assuming that the co-efficient of friction between the cypress log and the bill is 0.097 and that there is negligible resistance to diffusion, how many units of Vitamin B-1 will the woodpecker require to peck out enough shingles for a $7,500 barn with a detachable chicken house?

(The woodpecker has an efficiency of 97% and gets time and a half for overtime.)

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Thermometers – Something else graduated with degrees without having brains.

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One caveman to another: "Say what you will, we never had this crazy weather until they started using those bows and arrows."

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The best way to get rid of fleas is to take a bath in sand, then rub down with alcohol. The fleas get drunk and kill each other throwing rocks.

* * * * * * * *

Wife to husband: Is it true that you found your senior year at the U of W the happiest three years of college?

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What's the hurry?

I bought a new textbook and I'm trying to get to class before the next edition.

* * * * * * * *

The current re-emphasis on education is typified by one university that ruled that no athlete can be awarded a letter unless he can tell at a glance which letter it is.

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A certain Chemical Engineering Prof was unpacking some glassware he had received from the factory.

Finding one jar that was upside down, he exclaimed, "How absurd, this jar has no mouth!"

Turning it over he was more astonished. "Why, the bottom's gone too."

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The statisticians tell us that the chances of there being a bomb on an airplane you board are about one in five thousand. The chances of there being two bombs on board are one in fifty thousand. If you use your head and take a bomb with you, the odds are better.

* * * * * * * *

Engineering lectures are like steer horns – a point here, a point there, and a lot of bull in between.


70

# Even if you don't like the air you breathe, you can't stop breathing.

When was the last time you went out for a breath of fresh air and got it? How long has it been since the sky looked really blue?

Every day, our cities dump hundreds of thousands of tons of waste into the air. Carbon monoxide. Sulfur dioxide. Fluoride compounds. And plain old soot.

If something isn't done about air pollution in your lifetime, it may cut your lifetime short.

Air pollution can be controlled. The key is technology. Technology and the engineers who can make it work.

Engineers at General Electric are working on the problem from several directions.

Rapid transit is one. In many cities, the automobile causes more than half the air pollution. In some cities, as much as 90%. But engineers at GE are designing new equipment for rapid-transit systems, encouraging more people to leave their cars in the garage.

Another direction is nuclear power. General Electric's engineers designed the very first nuclear power plant ever licensed. A nuclear plant produces electricity without producing smoke. And as the need for new power plants continues to grow, that will make a big difference.

There are other ways General Electric is fighting air pollution. Maybe you'd like to help. We could use your help. But don't expect to come up with an overnight solution to the problem.

The solution will take a lot of people, a lot of talent and a lot of time. You'll breathe easier—once you get started.

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