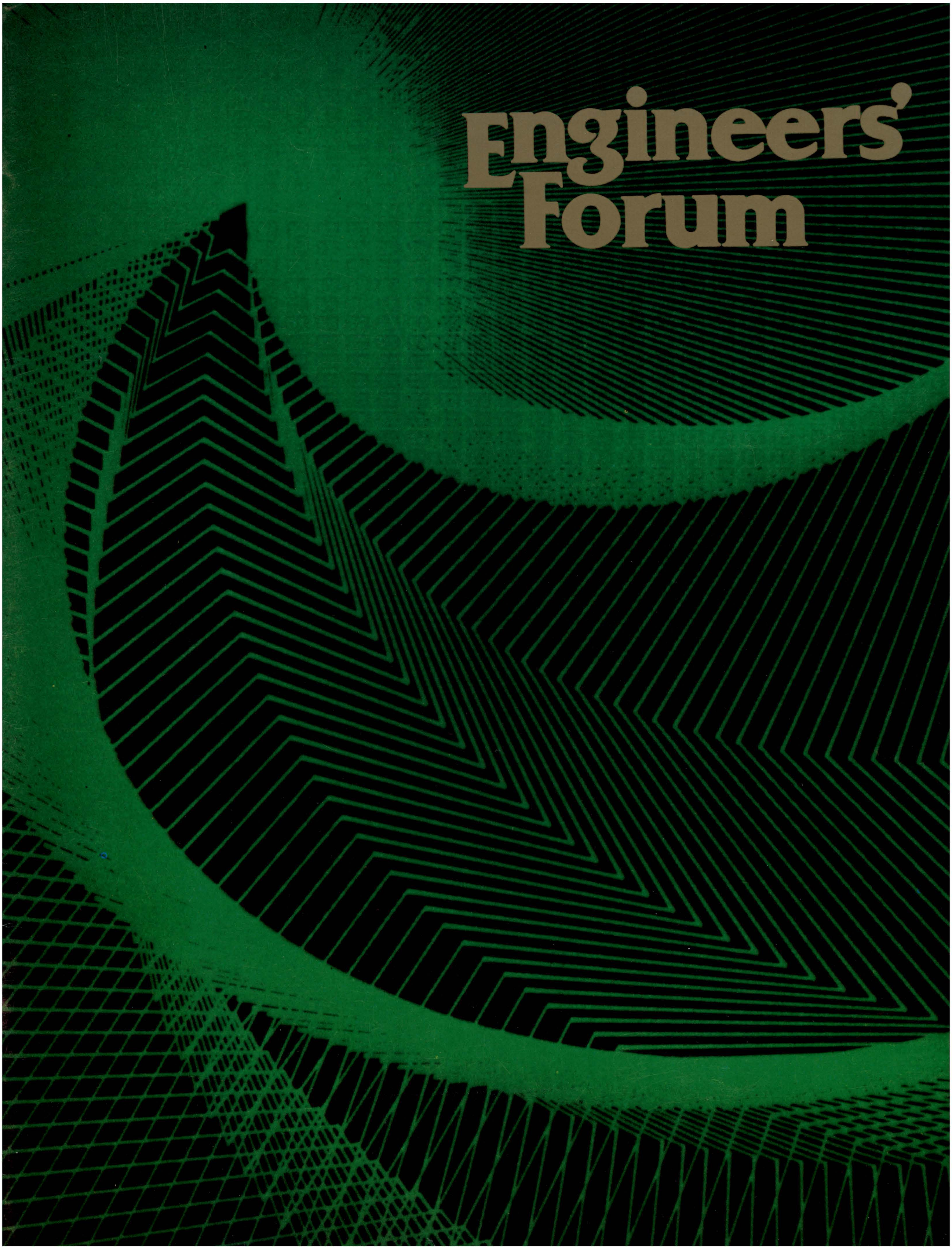
Engineers' Forum



Engineers' Forum

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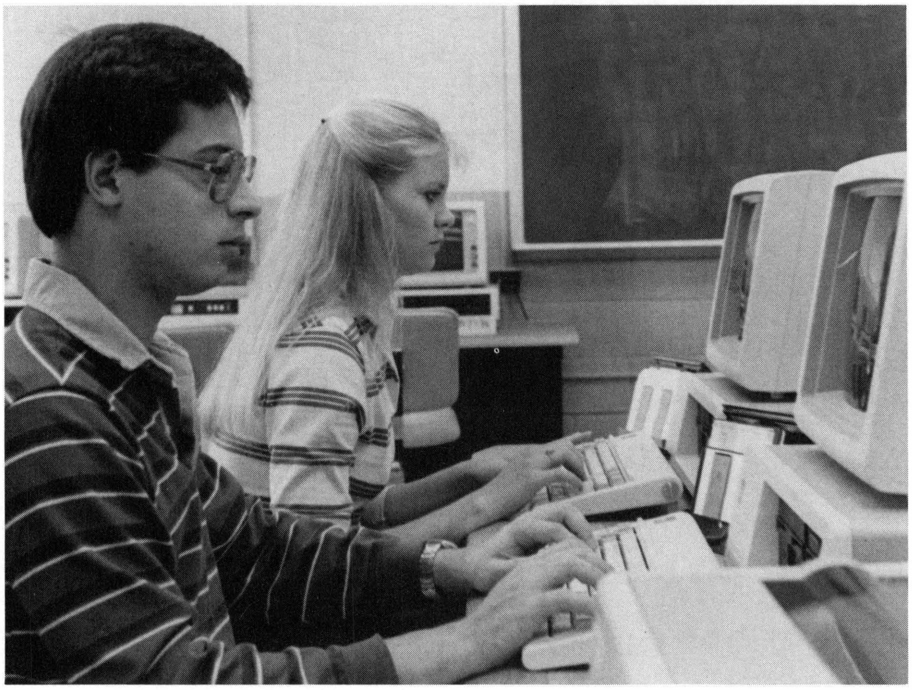


M. Hill

Welcome back. While you were away our staff was working diligently to put together this issue of the Engineers' Forum. Take a close look at what we have inside; I think you'll be interested in finding what we have to offer.

This year marks the third year that the Forum has been in print. Increases in advertising and the size of our staff have allowed us to bring you an increasingly better magazine, but we aren't totally satisfied. We take our work for this magazine seriously and we feel that it is an important resource within the College of Engineering.

The fact that most engineering students, not only Tech students but others from all over the country, have difficulty communicating has become increasingly evident. At the last meeting of the Engineering College Magazine Association certain schools expressed their desire to limit the competition, for any award given to a writer, to engineering students. We do not support a policy that implies an inferior degree of literacy among our staff writers who happen to be engineers. The inability of other engineers to communicate should not reflect on Virginia Tech. It is the goal of this magazine to allow engineering students to develop their communications skills, not to further the misconception that engineering students have an inherent inability to write.

Unlike other schools, Virginia Tech requires all engineering students to take a year of English. Contrary to the opinion of some students, this is not a waste of time. A year of English not only serves to polish writing skills, but also provides a starting place for communications skills that will prove essential later. If you would like to develop your communications skills further by contributing to the Forum let us know; we won't turn you away.

Enjoy the rest of the magazine. Perhaps it will inspire some of you to contribute an article. Let us know your opinions about the magazine, its articles, or its format. Mail your letters to:

Letters to the Editor
Engineers' Forum
337 Norris Hall
Virginia Tech
Blacksburg, VA 24061

Michael R Dietrich

A New Era Begins

The 1,200 freshmen engineering students who arrived on campus in the fall of 1984 were like the rest of the University's entering students in most respects. They too resembled circus performers juggling suitcases, stereo equipment, and pillows as they made their way to their dormitory rooms. But these freshmen were different in one very important way: each of them also caried a brand new personal computer.

Thus began a new era for Virginia Tech's College of Engineering because the university had just become the first large public institution in the U.S. to require each entering freshman to purchase a personal computer (PC). The college began studying the idea of having such a requirement in 1982 when it established a committee chaired by engineering science and mechanics professor Carl T. Herakovich to study the pros and cons of having students buy their own computer. By the following spring. the committee suggested that the purchase of a personal computer by engineering freshmen be mandatory by the 1985-86 academic year. Dean Paul E. Torgersen accepted the report with one modification–the program would start one year earlier than recommended.

M. Hill

Once the decision was reached, the college moved ahead full speed. Fifteen computing vendors were asked if they were interested in submitting bids, and seven companies said yes. Of the seven, four were visited personally by Torgersen and/or Herakovich. Another committee member, Mark Davis of the chemical engineering department, was asked to participate in the final evaluation. By the end of the summer, the choice had narrowed to Texas Instruments, Zenith, DEC, and IBM.

At this time the college realized that it would need a full-time administrator to handle the logistics of a program of this size and complexity. For example, someone would be needed to coordinate the initial purchase of the computers by the university and the eventual resale of individual units to students. The complete program would cost the University approximately $2.4 million in the initial investment. So, in September 1983, electrical engineering associate professor Charles E. (Butch) Nunnally was selected as the new assistant dean for engineering computing. Nunnally had served as the chairman of the computer engineering group within the electrical engineering department.

In September the college announced that it had chosen IBM to provide personal computers to engineering students. Articles on the agreement apperared in the *Wall Street Journal, Washington Post, Chronicle of Higher Education,* and several other national publications. The *Post* quoted Torgersen as saying that the personal computers would allow the College of Engineering to "remain at the cutting edge of engineering instruction," a significant statement when combined with the facts that the college is continually among the top ten of the largest undergraduate engineering instiutions in the nation, and its students' scholastic abilities are among the best in the state school category.

In preparation for the 1984 academic year, IBM shipped 150 PCs to the campus in early December. This equipment was used to establish two instructional laboratories. During winter and spring quarters, the laboratory sessions provided learning opportunities on the PCs for most of the approximately 5,000 enrolled engineering students. Faculty members also received PCs so they could become familiar with the units.

In the meantime, Nunnally began receiving issues of 15 different computing magazines, and reading the business section of the *Wall Street Journal*. "I browse those magazines each week and intently read two or three. I read the *Journal* because this requirement is not just an engineering decision, it's also a business decision."

The business end of it includes the maintenance of thousands of machines which will be done within the college, the financing of the PCs through the university, the purchase of the correct software, the training programs for the faculty, and a feasible distribution plan.

Another thing Nunnally had to do was let prospective students know they had a choice of IBM units. To do this, he sent a letter to each student listing the options: the single disk PC portable, the dual disk PC portable, the PCjr, and the PC. The students were also given the costs, descriptions, advantages, and disadvantages of each system. The college recommended the single disk portable PC "as the most suitable and appropriately priced system."

If parent or students had any questions, they had three weeks to call a PC "Hotline" established by the college and run by its Student Engineers Council. The SEC handled 150 telephone calls during that period.

Of the incoming freshmen, 90 percent chose to purchase the portable PC. Another five percent selected the PCjr, and the remainder requested a PC. Forty-five percent of the students who chose the portable PC opted for the budget plan whereby they could stretch their payments over 18 months. Nunnally points out that IBM has since announced a price reduction to the university which, in turn, will be passed on to the students.


M. Hill

Nunnally has also been concerned with the security of the PCs in the dormitory rooms. To help solve this problem, all of the computers will have their serial numbers recorded as they are distributed.

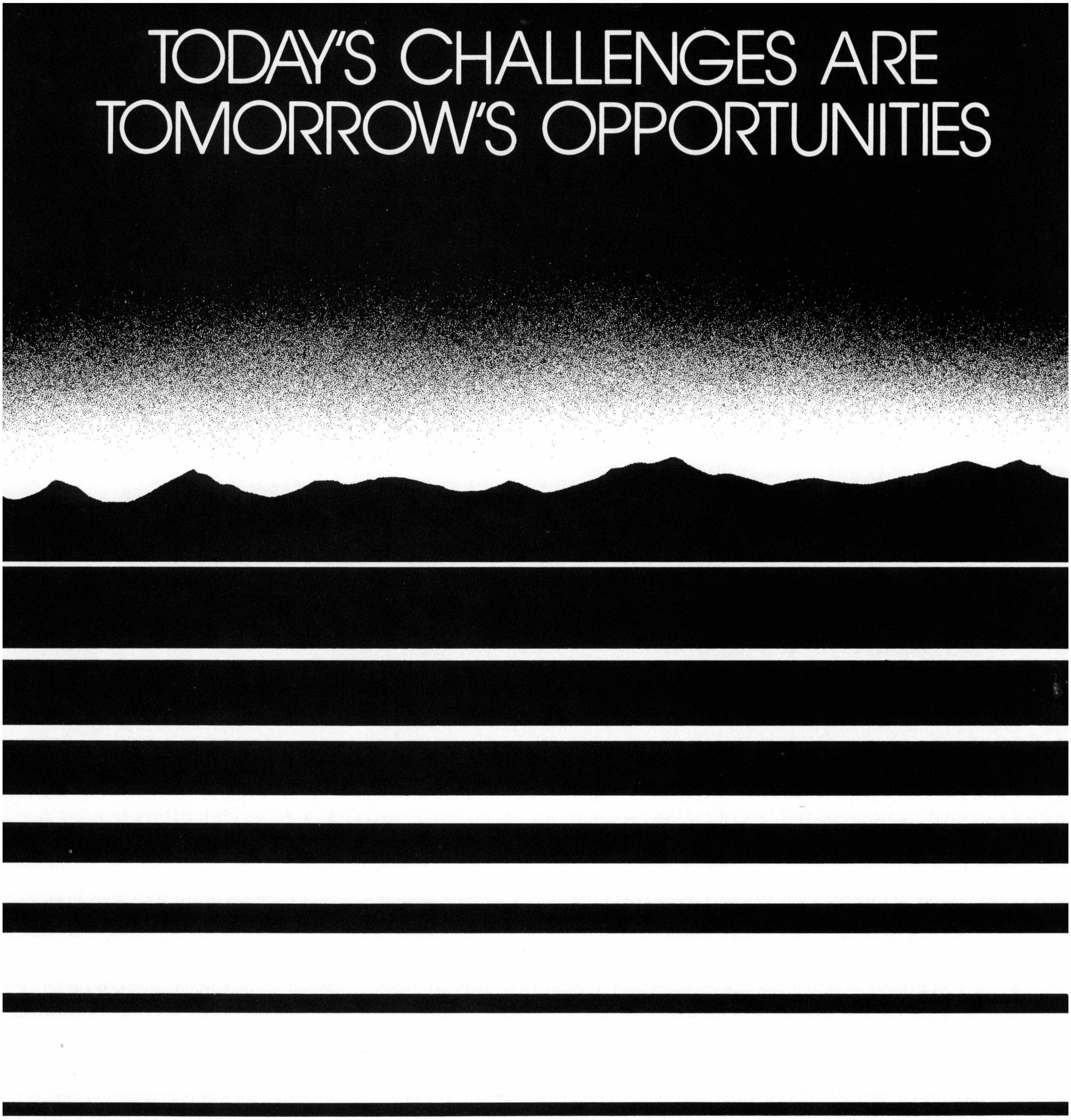
Because the machines must be serviced after the students buy them, the college's technical staff members attended IBM maintenance courses to learn how to solve problems that might occur. IBM has authorized Tech to perform this service for its company, and IBM is ultimately billed for any repair work, Nunnally explains. The college has established a loaner service in the event a machine cannot easily be fixed. All of the systems' warranties have been extended to two years. "This service only amounted to an additional seven percent of the entire cost," Nunnally says.

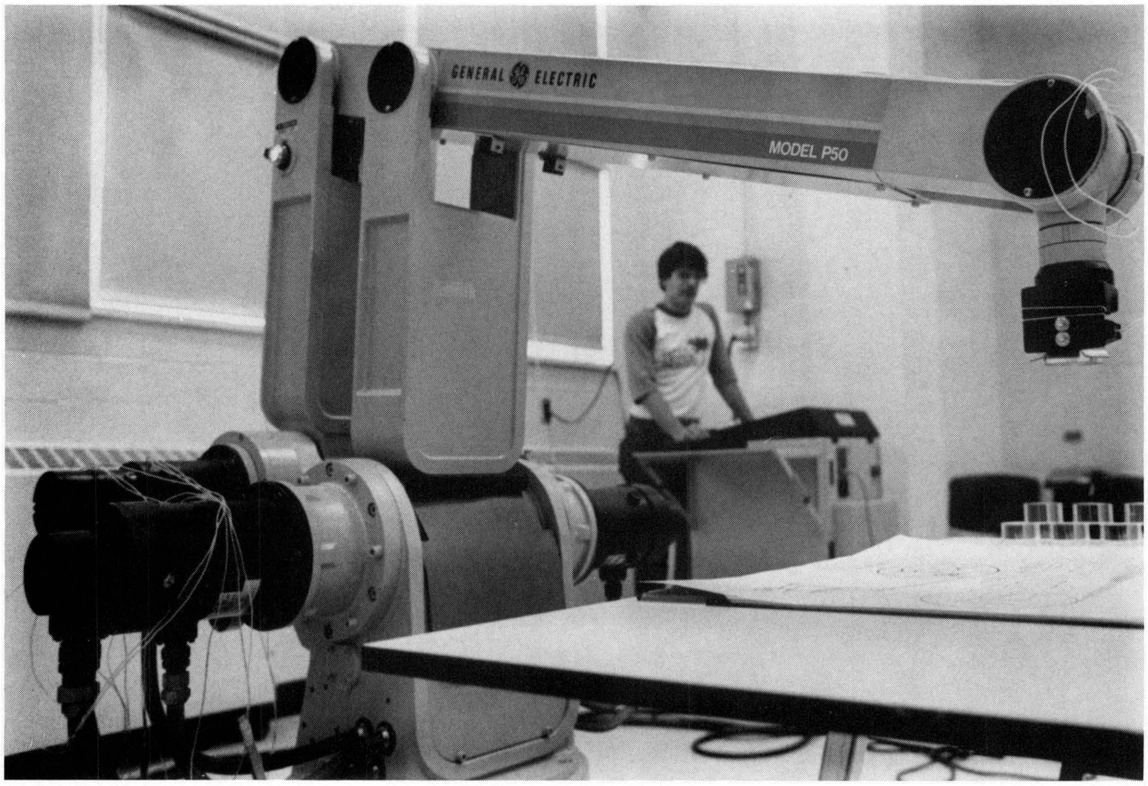
The assistant dean also incorporated a software allowance in the budget for the purchase of a operating system, BASIC, screen editor, word processor, and FORTRAN compiler.

Because of the magnitude of Virginia Tech's effort to modernize its educational instruction in engineering, IBM has placed one of its representatives on-campus in a full-time capacity. "Less than 120 places in the country are offered this type of attention from IBM," says Nunnally. "And because of this large-scale effort, Academic Computing Information Systems is directly supporting us."

And now that Nunnally has gone through the proces of working personal computers into an engineering program, he will offer to share his successess and frustrations with other universities at a conference on this subject at Virginia Tech this coming winter.

by Lynn A. Nystrom


TODAY'S CHALLENGES ARE
TOMORROW'S OPPORTUNITIES



M. Hill

Robotics Comes of Age at Va. Tech

Yes, it's true! The mechanical engineering department has a robot. In fact it is the only robot on campus. Many other departments have microbots, but thanks to General Electric, the mechanical engineers have a sophisticated 5-axis robot that cost GE approximately $60,000. Last year Associate Professor Said Zewari began teaching robotics as a special study project to senior mechanical engineers and graduate students. The growing interest in robotics by Professor Zewari and the mechanical engineering students prompted the department to answer an offer from GE for free equipment. The ME department asked for a robot and was granted one of 19 that were disseminated nationwide. This robot is Virginia Tech's first real step towards robotics.

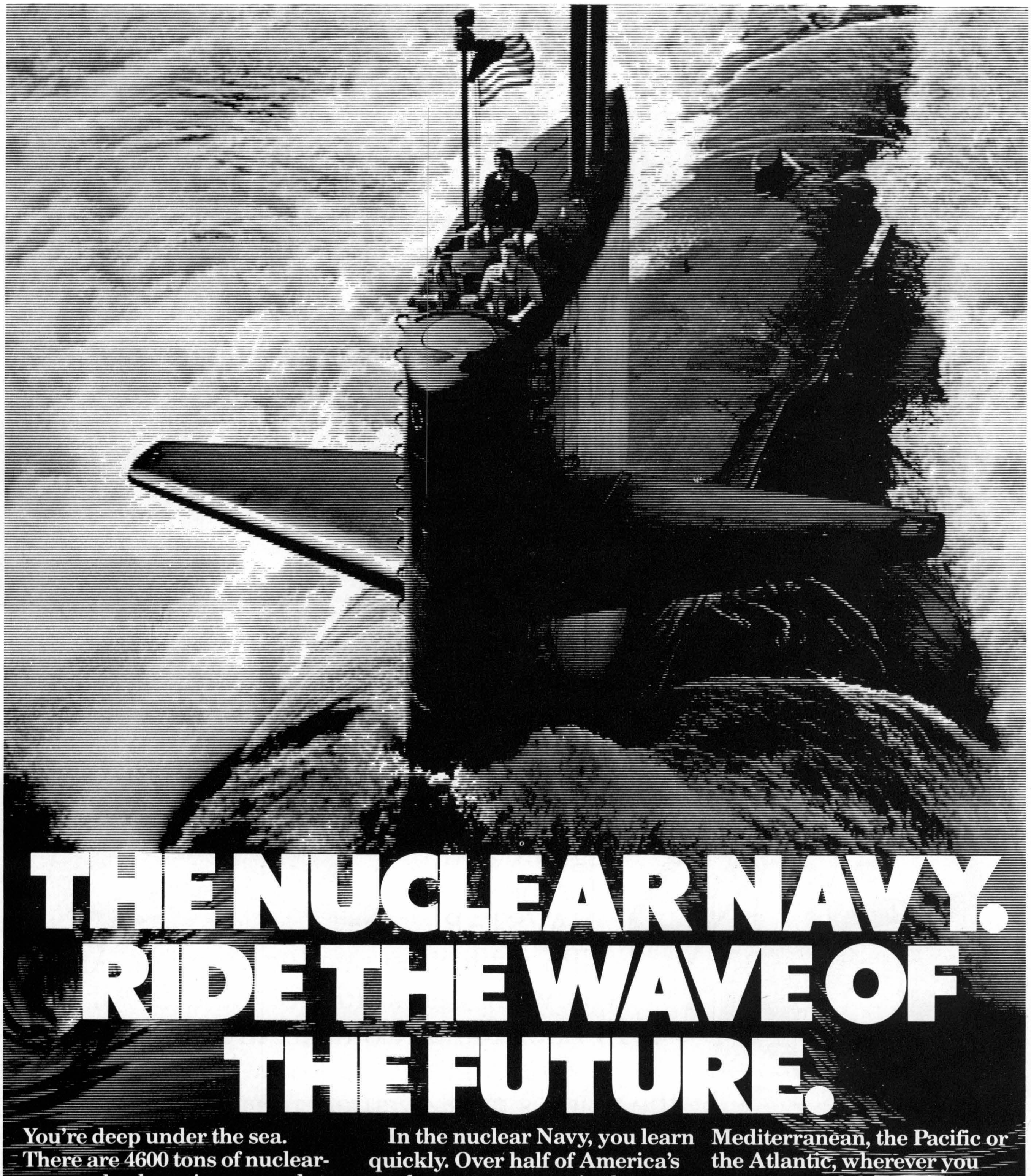
Within the last year there have been three classes on robotics taught by Prof. Zewari, and the classes have gotten progressively more basic by the demand of the students. Professor Zewari's main objective is an introduction to robotics with an emphasis on kinematics, dynamics, and controls. Robotics is a very complicated and intricate field because to understand the science, one must have a knowledge of programming, controls, and dynamics. Robots are significantly different from classical machinery because they are an automaton in association with computers. Through a simple electonic pulse, an operator can stop a task that a robot has done, possibly 50 iterations of, and have it start doing something else. Classical machinery is incapable of these interruptions. Robots are not as durable as classical machinery because of their frequent jerky motions which cause large amounts of vibration, but they present a completely new outlook on automation.

The technology of robotics encompasses many different fields. Mechanical engineers, who concentrate on kinematics, dynamics, and controls are different from computer science majors whose main objective is programming. Industrial engineers are concerned with the integration of robots with other robots and classical machinery in the factory, and electrical engineers emphasize the controls aspect. All these fields work together to successfully operate a robot.

Robots, although visualized by many as being single self-sufficing units, actually consist of many separate entities. The robot mechanism consists of the actual body of the robot, which has five axes, a box which can control the motions of the robot individually, a sophisticated computer which stores the programs and holds the main information, and an input/output port, created by the ME department, which is used to give electronic pulses. Although only a small amount of research is being done on the robot because of a lack of graduate students that have the background needed to start immediately, students presently taking the class do create simple programs which order the robot to pick up certain blocks and put them in certain locations. With these programs and some electonic pulses, students create jobs which may dictate many different tasks to the robot.

Robotics is a dynamic field because it represents a space age phenomena, and also because of its practicality and adaptability to the industrial system.

by Christina L. Dugan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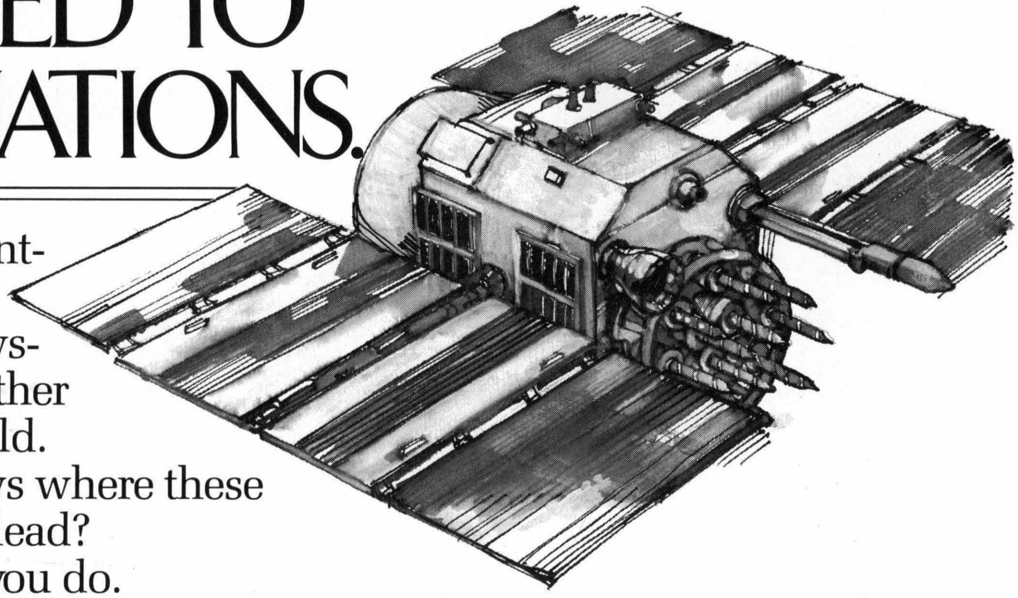

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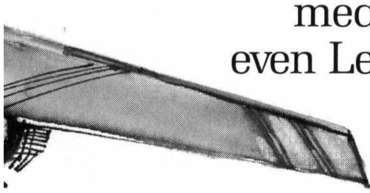

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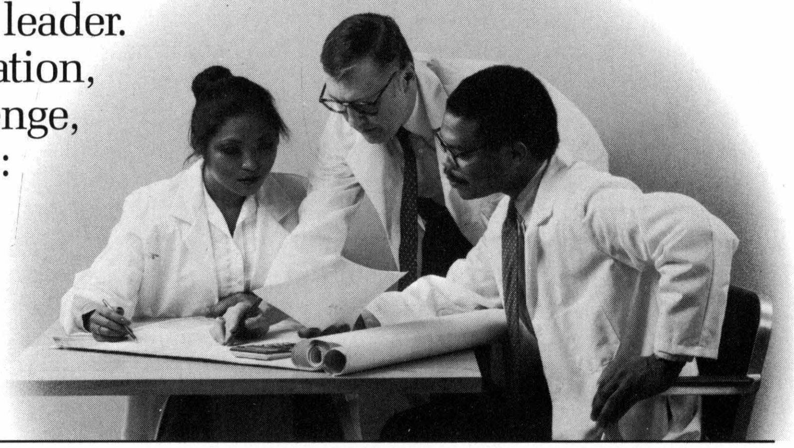

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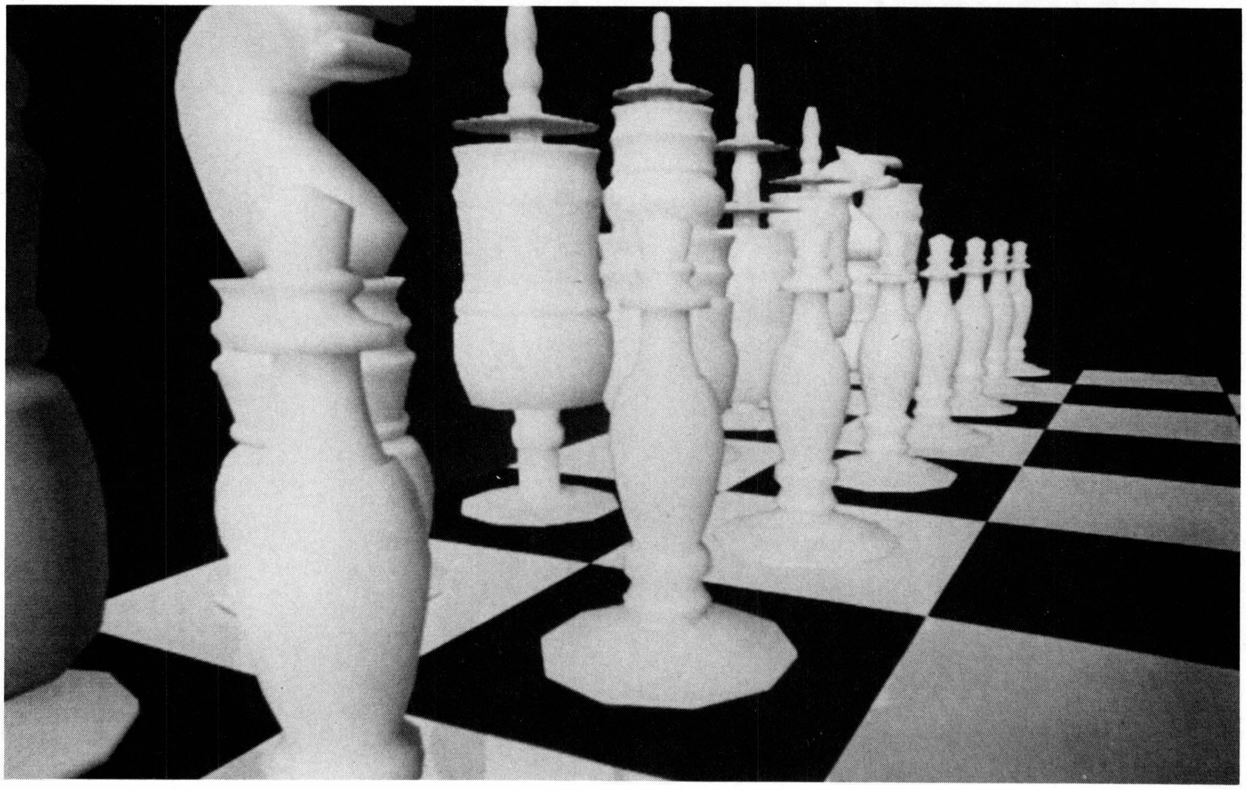


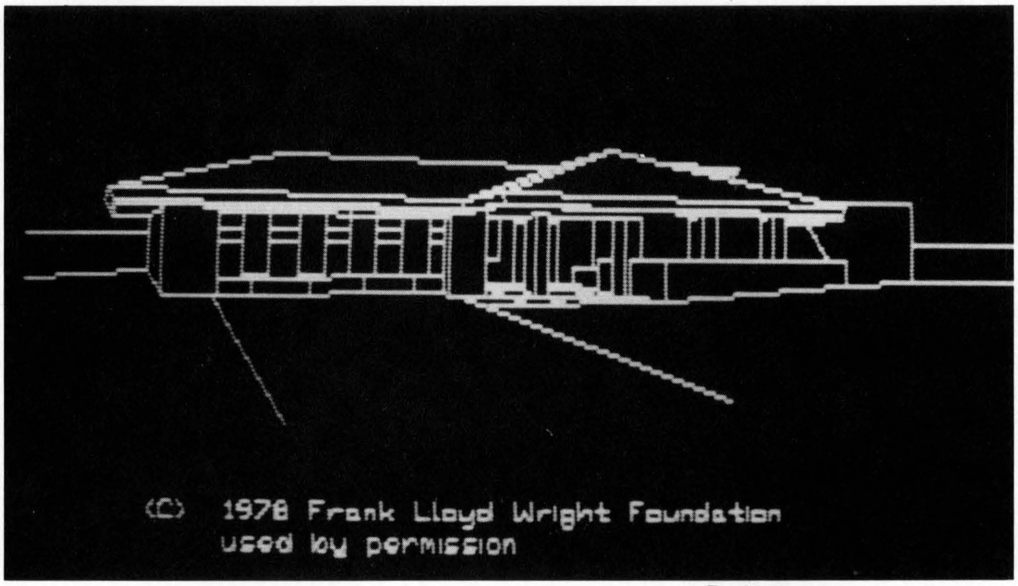
S Frazer

Computer Graphics

A picture is worth a thousand words. Recently, this cliche has taken precedence in the field of computer technology. Computer graphics do more than just replace a host of words that paint unclear mental images. Graphics also enable engineers to display their designs with great accuracy, as well as show these designs in motion. Aside from their utility as an informative display, engineers are finding that plans drawn with computer graphics can be done more efficiently than sketching designs with pencil and paper. Many times pencil and paper graphics have to be redrawn several times to correct mistakes, but plans written with computer graphics have the advantage of being stored on a disk. Once the plans are stored, the engineer can easily edit designs in much the same way manuscripts are edited in a word processor.

Now engineers can draw their computer graphics much in the same way they sketch pencil and paper graphics. Through peripherals, they can actually bypass the keyboard and make accurate, time saving designs in the computer. Anyone who plays video games uses a peripheral everytime they maneuver a joystick. Another peripheral, the graphics tablet, has been used to bypass computer keyboards for many years. Graphics tablets resemble the popular children's toy, the Etch-a-Sketch. Two sheets of special film cover the graphics tablet. One sheet gives the horizontal command while the other sends the vertical command. The engineer traces the design on the tablet by pressing these sheets of film with a stylus. As the image is being traced, the design appears on the screen.

For the feeling of actually drawing on the screen, the light pen, another peripheral, can give you the old security of paper and pencil graphics. The light pen electronically draws images directly on the video screen. By moving the light pen along the screen, you can watch your sketch appear like you do with pencil and paper graphics. This time saving device is a phototransistor (light activated switch) housed in a plastic cylinder. The phototransistor has an advantage over the graphics tablet in that it not only communicates with the computer, but also responds to the video monitor. You don't have to worry about learning a lot of new sophisticated commands for the graphics tablet and light pen. Both of these devices have various software packages that offer editing and several programs for color and monochrome designs.

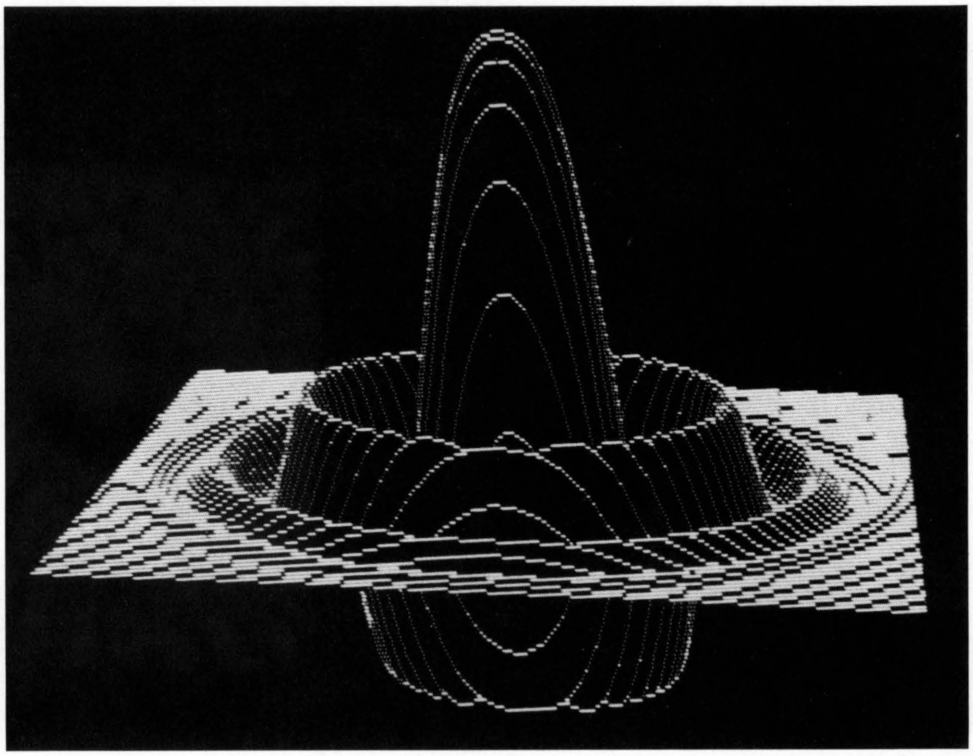


Dr K Rojiani

No matter with which peripheral device or software you choose to program your graphics, the applications for computer graphics are as varied and endless as the engineering endeavors they display. Computer graphics offers the flexibility of editing diagrams by moving or changing the angle of lines or curves. Through different programs, the computer can detect flaws in your diagrams, thus enabling you to correct problems in the early stages of your work. Since you can easily shift angles, lines and curves, you can store each phase of your system's movement. By doing so, the computer can display how effectively the designed system performs in motion. In addition to presenting an effective system in motion, nothing sells a prospective contract better than graphs explaining the system's advantages. Such graphs could map out cost/benefit analyses and cyclic test results.

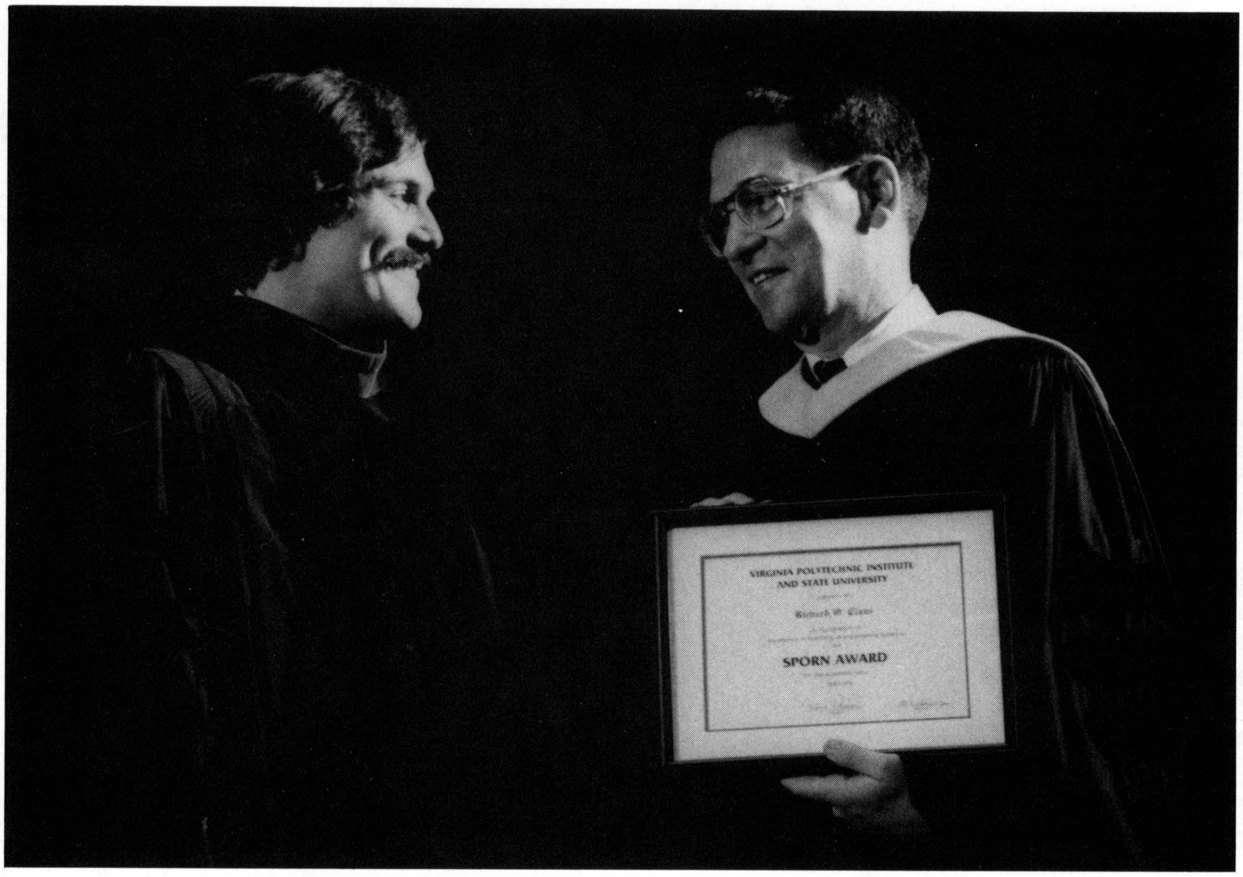
Not only are computer graphics far more versatile than pencil and paper graphics, their speed of mobility is exceedingly greater than the old method of graphics. Through phone modes, your computer graphics presentation can travel around the world in a matter of seconds without the fear of postal damage. Computer graphics' versatility, combined with their superior mobility, are giving engineers the edge that they need in today's field of escalating technology.

by Bill Duncan



M. Hill

Faculty Profile



Provost Roselle (r) presents the Sporn Award to Dr. Claus. *K. Bible*

Sporn Award 1984

Dr. Richard Claus

The engineering students of Virginia Tech have chosen Dr. Richard Claus as the 1984 recipient of the Sporn Award. This award recognizes the most outstanding undergraduate professor in the College of Engineering.

Dr. Claus came to Virginia Tech in the fall of 1977 after receiving both his B.S. and PhD. from Johns Hopkins University. He decided to go into teaching and research because of his experiences as a graduate student, during which he enjoyed working with the students and on various research projects with people outside his department. He especially enjoyed the flexibility presented by being at a university.

Dr. Claus's involvement with students does not end with the classroom. He advises graduate students on projects and helps undergraduates with independent studies. He is also the advisor for the electrical engineering honor society and WUVT.

Dr. Claus learned more than decimals from his seventh grade math teacher; he learned the ABC's of good teaching. "A good teacher must possess Ability, Brains, and Color. The teacher must be able to interact with the students so that they get something out of the course, the teacher must know what he is talking about, and the teacher must be enthusiastic and able to excite the students into learning."

Dr. Claus considers the Sporn Award the greatest award he has ever received because he was chosen by the students. He really appreciates what the students feel. He is truly sorry to see the end of the school year come when many of the students he has worked with leave Virginia Tech. His outstanding teaching ability and dedication to his students make Dr. Claus a truly worth while recipient of the 1984 Sporn Award.

by Debby Dutton

Cybernetics:

A Link Between Man and Machine

By far the most versatile mechanism ever identified is that itself which identifies: the hallmark of our phylum called the central nervous system. It is all those grey and white cells that compose the brain and the spinal cord (cells known as *neurons*), and it is a great fraction of the universe as well.

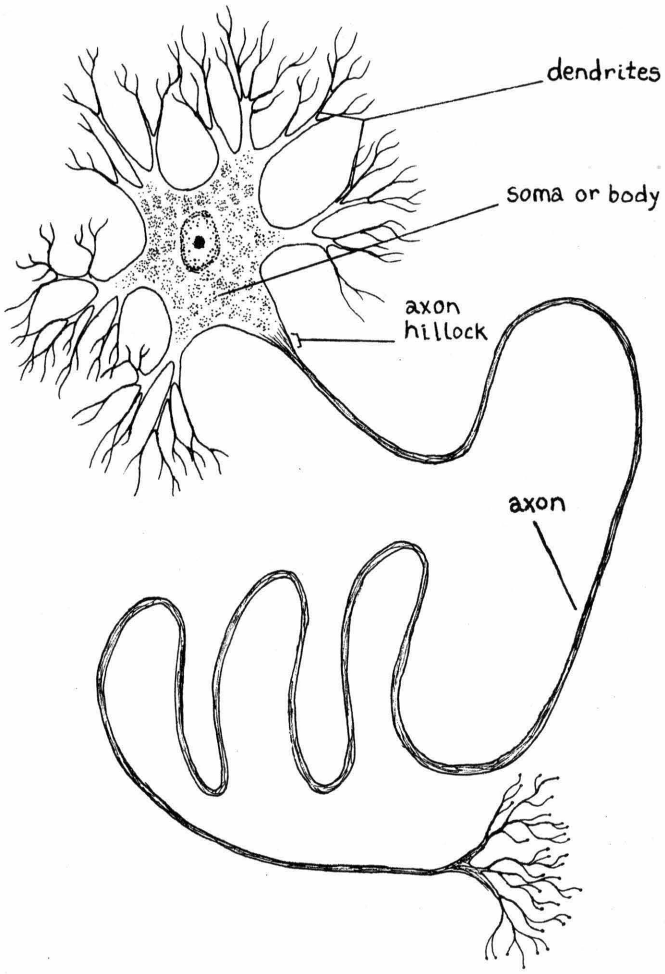
Cybernetics is the science that has evolved around a curious marriage of disciplines: the studies of this universe of a mechanism, and the studies of the devices this mechanism has developed–the computers and calculators and robots. Only recently has the utility of this field of cybernetics come to the attention of engineers, but increasingly a need to locate our own selves on this map we call science is arising; after all, we comprise the most prominent features of the territory, and yet we are all but missing from the map.

Today the artifacts of engineering are entailing more and more elaborate and quote intelligent unquote designs. Even wristwatches today often involve a remarkable ability to make simple decisions.

Yet what our most sophisticated creations are capable of is still child's play compared to what the simplest of living central nervous systems are capable of. The slug known as the aplysia, in fact, encompasses more decision-making capability than an IBM 4341.

So an imperative exists today–within the whole discipline of engineering–to apply what we know of this mechanism. The tools we need are found in cybernetics. Accordingly, the purpose of this article is to explore one possible means of simulating the atom of all nervous systems–the neuron. Clearly, to be able to model one neuron is, in theory, to be able to model a set of them–or even an entire nervous system.

Figure 1: "Example of a neuron"



The Mechanics

On what basis, then, will the neuron be modeled? When a doctor raps on a patient's knee with a hammer, he or she distorts a cell embedded within the muscle–a cell called a *stretch receptor*. The stretch receptor has certain electrical properties that become distorted according to whatever elastic deformation results; as a consequence, a sensory neuron adjacent to the stretch receptor triggers a series of what are called *action potentials.* These waves of depolarization (very different from simple electric currents) propagate actively along the length of the sensory neuron until they reach the tip where microscopic quanta of organic compounds are released that rapidly (assuming the knee jerks) trigger similar trains of action potentials in subsequent neurons of the circuit until finally a so-called motor neuron excites a statistical proportion of muscle cells and the classic if trite knee-jerk reflex ensues. The key point is that, whatever the level of stimulation a neuron is subject to, the action potentials by which it communicates its excitation to subsequent neurons nearly always have virtually the same amplitude. Studies, in fact, have demonstrated beyond reasonable doubt that neurons communicate by means of frequency modulation (or temporal coding, to use the neurophysiological jargon) as opposed to amplitude modulations. Thus the natural basis for modeling the neuron is the frequency of action potentials (also called spikes)–or the *discharge rate.*

A neuron has a distinctive look, and before the reader continues, he or she would benefit from examining Figure 1, which depicts a neuron spread out as though on a microscope slide. Notice the four important parts labeled. Most prominent on a typical neuron is the long part, called the *axon,* which joins the lumpy *body* or *soma* at the junction called the *axon hillock.* What resemble the branches of this tree trunk of a cell are called *dendrites.* Action potentials originate at the hillock and travel strictly (in most cases) orthodromically, meaning in the direction away from the soma, within the axon. The electical distortions due to action potentials from preceding neurons impinge upon sites called *synapses* located along the dendrites. Electrical waves that spread out passively from these synapses are called *post-synaptic potentials:* unlike action potentials, they radiate in all directions and attenuate with distance.

An engineer learns quickly the importance of *defining* a task. Without further ado, then, I will propose a scenario depicting where we stand and where we want to arrive.

Given a neuron whose properties are known, and given how post-synaptic potentials are being generated by previous neurons at the synapses, and given the effective locations of all these synapses in terms of some idealized, homogeneous, isotropic cell membrane, a person should be able to determine how action potentials will be generated by the neuron (i.e., one should be able to predict the discharge rate as a function of time). A picture such as Figure 2 illistrates this object well.

Some definitions:

(1) AP "action potential number"
$AP \equiv$ the actual (i.e., step-function-like) count, in whole cycles, of action potentials propagated thus far

(2) $\widetilde{AP}$ "streamlined action potential number"
$\widetilde{AP} \equiv$ the streamlined (i.e., continuous) count, in fractional cycles, of action potentials propagated thus far

The reader should keep in mind, upon trying to understand these definitions, the goal of the model: definitions (1) and (2) apply not to givens but to unknowns–or to two alternative means of representing the same unknown.

(3) $\dot{AP}$ "action potential frequency" or, alternatively, "discharge rate"
$\dot{AP} \equiv \frac{dAP}{dt}$ where AP is in Hertz

Notice the utility of the dot and streamlining notations. Figure 3 illustrates the nature of these subtle distinctions.

(4) PSP_j "post-synaptic potential number" or, alternatively, "impingement"
$PSP_j \equiv$ the actual (i.e., step-function-like) count, in whole cycles, of post-synaptic potentials impinging upon synapse j thus far

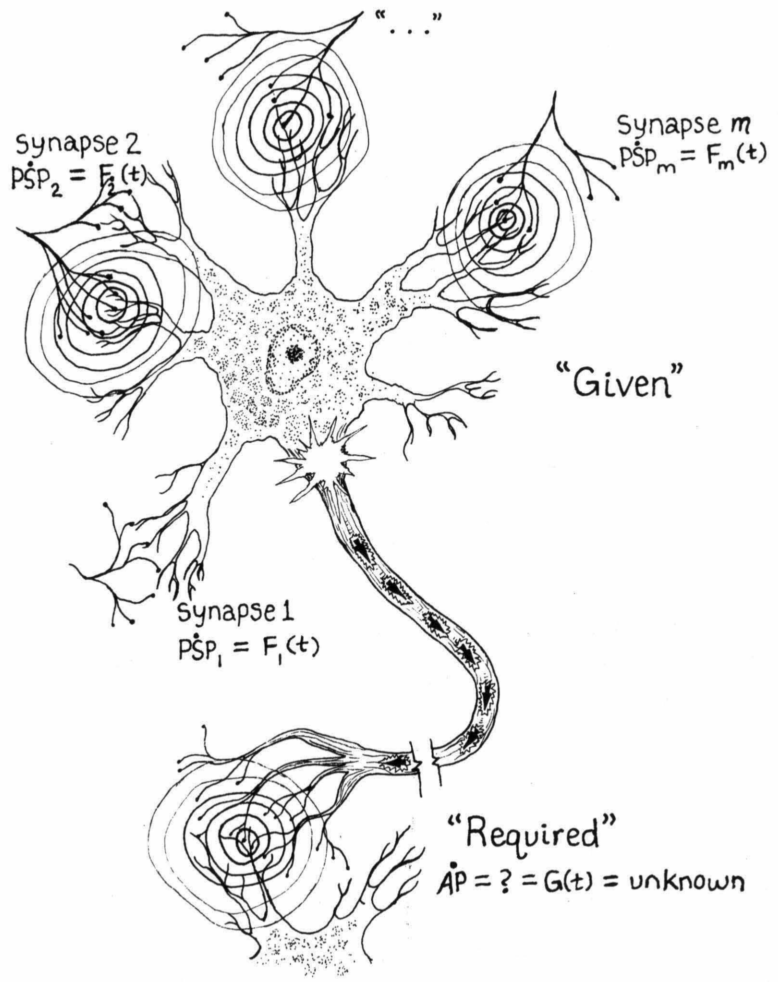


Figure 2: "Object of the model"

(5) $\tilde{PSP}_j$ "streamlined impingement"

$\tilde{PSP}_j \equiv$ the streamlined (i.e., continuous) count, in fractional cycles, of post-synaptic potentials impinging upon synapse j thus far

(6) $\dot{PSP}_j$ "post-synaptic potential frequency" or, alternatively, "impingement rate"

$\dot{PSP}_j = \frac{dPSP_j}{dt}$ where, first, $\dot{PSP}_j$ is in Hertz and, second, j identifies the source of (synapse associated with) the impingement rate.

Notice that, as a rule,

(7) $\tilde{AP} \doteq AP$ where $\tilde{AP} \geq AP$, and
(8) $\tilde{PSP} \doteq PSP$ where $\tilde{PSP} \geq PSP$

–the reason: because the non-streamlined numbers represent the truncated integer parts of the streamlined ones.

Like Figure 3, Figure 4 illustrates the similar natures of the post-synaptic potential numbers and rates.

Next, consider a control volume around the axon hillock. Whenever the voltage across the control surface exceeds what is called the *threshold* voltage, the hillock will trigger an action potential–provided the so-called absolute refractory period of time has elapsed. The hillock acts like a water tank that flushes whenever a certain volume of water has entered it. The net effect of a post-synaptic potential on the axon hillock is a temporary elevation in the local voltage whose magnitude depends on the effective separation of the hillock from the synapse where the post-synaptic potential originated; a PSP is analogous to an influx of water. The net effect of an action potential, on the other hand, is a change in the local voltage equal to the difference between the threshold and resting voltages, because a spike (action

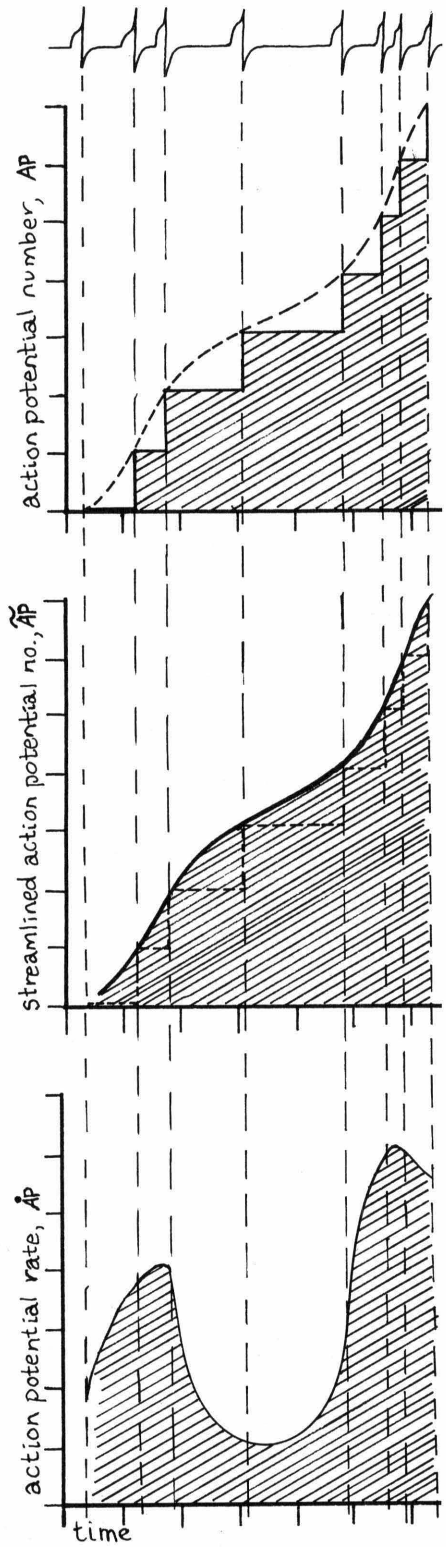


Figure 3: "Action Potential numbers and rates"

potential) *begins* when the local voltage has been elevated to the threshold potential (which shall be written V_{cr} henceforth) and *ends* when it has returned to the resting potential (V_{mho} henceforth); an AP is anlogous to a flushing of the tank.

The hillock voltage depends on action potentials (which reduce the voltage) as well as post-synaptic potentials (which elevate the voltage); however, action potentials are functions of post-synaptic potentials and therefore the hillock voltage would seem to reduce to a function of the post-synaptic potentials.

Suppose, for a moment, that a tank were constructed that differed in function from a neuron in one important respect: whenever it flushed had nothing to do with how or when water entered the tank. Clearly, then, the water in the tank (the volume of it) is a function of the rates of influx and efflux. Next, consider the same tank, only rigged such that when it flushes depends on when water enters it. Is there a difference between the mathematical representations of the two tanks?

In that case, as well as its neural analogue, both of the originally independent variables are fundamentally functions of time and nothing else. Such concerns as "separation distances" are merely arbitrary constants, given a particular neuron. Therefore, in accordance with page 168 of the text by Angus E. Taylor called *Advanced Calculus,* the answer is no. Here follows what he says:

If U=F(x,y,z) where x=f(t), y=g(t), and z=h(t), then

$$\frac{dU}{dt} = \frac{\partial U}{\partial x}\frac{dx}{dt} + \frac{\partial U}{\partial y}\frac{dy}{dt} + \frac{\partial U}{\partial z}\frac{dz}{dt}$$

Accordingly, consider the following assumption:

Assumption *#1*

Exactly insofar as a hillock voltage measurement is distant in time from any and all discontinuities in the (actual) post-synaptic potential numbers impinging upon the neuron, it is a function of the (actual) post-synaptic potential numbers and the (actual) action potential number.

Mathematically,

(9) Far from discontinuities, $V = F(AP, PSP_1, PSP_2, \ldots, PSP_m)$ where $AP = g(t)$ and $PSP_j = f_j(t)$

Since, in reality, voltage must be continuous, it follows from (9) that

(10) $V \approx F(\widetilde{AP}, \widetilde{PSP}_1, \widetilde{PSP}_2, \ldots, \widetilde{PSP}_m)$ everywhere

Thus, from the text by Taylor,

$$(11)\ \frac{dV}{dt} \approx \frac{\partial V}{\partial \widetilde{AP}}\frac{d\widetilde{AP}}{dt} + \frac{\partial V}{\partial \widetilde{PSP}_1}\frac{d\widetilde{PSP}_1}{dt} + \frac{\partial V}{\partial \widetilde{PSP}_2}\frac{d\widetilde{PSP}_2}{dt} + \ldots + \frac{\partial V}{\partial \widetilde{PSP}_m}\frac{dPSP_m}{dt}$$

Assumption #2

Neglect the absolute refractory period (i.e., assume low discharge rates) as it is on the order of a millisecond.

The second assumption implies relatively long intervals between all potentials (or at least rates much lower than the maximum possible). From assumption #1, then, for "relativily long intervals" the voltage time derivative is exactly zero. To a reasonable approximation, then,

$$(12)\ \frac{dV}{dt} \approx 0$$

And so, solving (11) for what is sought,

$$(13)\ \frac{d\widetilde{AP}}{dt} \approx \frac{-\sum_{j=1}^{m}\left[\frac{\partial V}{\partial \widetilde{PSP}_j}\left(\frac{d\widetilde{PSP}_j}{dt}\right)\right]}{\frac{\partial V}{\partial AP}}$$

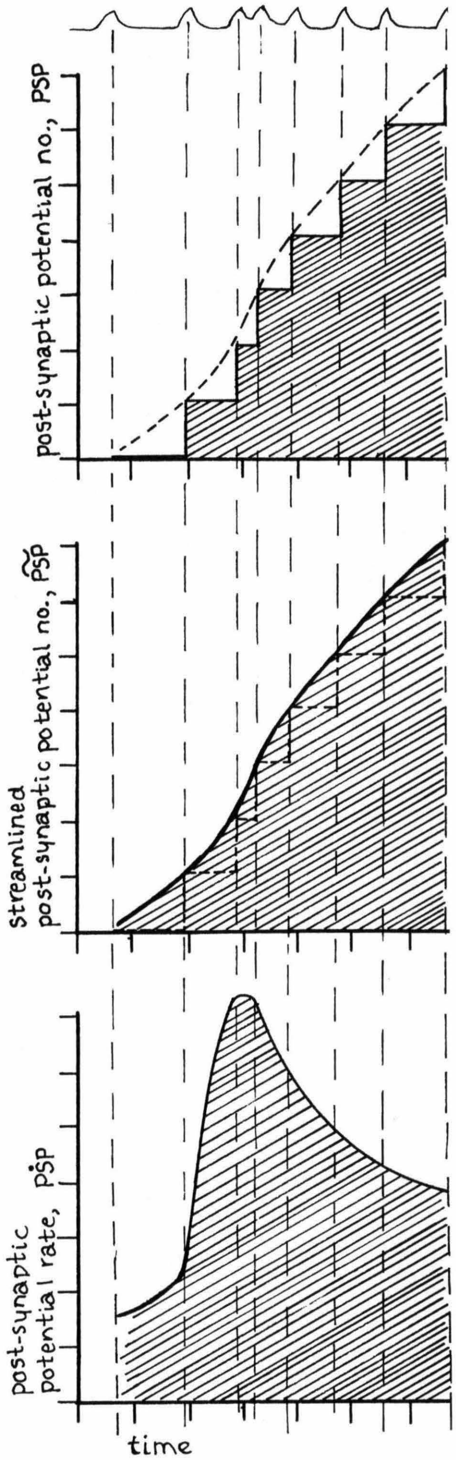
where the denominator may be recognized as a representation of the net effect of an action potential on the hillock voltage–already found to be

$$(14)\ \frac{\partial V}{\partial AP} = \left(V_{mh0} - V_{cr}\right) \text{per spike} = \left(V_{mh0} - V_{cr}\right) \text{spikes}^{-1}$$

Equation (13) may thus be rewritten

$$(15)\ \dot{AP} \approx \frac{\sum_{j=1}^{m}\left[\frac{\partial V}{\partial PSP_j}\dot{PSP}_j\right]}{V_{cr} - V_{mh0}} \text{spikes}$$

Figure 4: "Impingement numbers and rates"



The electrotonic relation

$$(16)\ V = LAMBDA^2\frac{\partial^2 V}{\partial x^2} - TAU\frac{\partial V}{\partial t}$$

(where

(17) $TAU = R_m * C_m$ "time constant" for which R_m is membrane resistance (in ohm-cm^2) and C_m is membrane capacitance (in microfarads/cm^2) and where

(18) $LAMBDA = \frac{1}{2}\sqrt{(D)R_m/R_i}$ "space constant" for which D is dendrite diameter, R_m is as before, and R_i is specific resistance of the axoplasm)

defines the spatiotemporal decay of a passively propagated pulse such as a post-synaptic potential.

For the moment, substitute U for V in (16) and let r(x)=TAU; p(x)=LAMBDA^2; q(x)=1; and F(x,t)=0. The result is

$$(19)\ q(x)\ U = p(x)\ U_{xx} - r(x)\ U_t + F(x,t)$$

which is identical to

$$(20)\ r(x)\ U_t = (p(x)\ U_x)_x - q(x) + F(x,t)$$

which is precisely the "well known" diffusion equation, a species of Laplace's equation.

Assumption #3

It is caled "stationarity" in neurophysiology, and it means a neuron now is a neuron later. In other words, the fundamental properties of a neuron change little: the same neuron will produce the same output given the same input later. This assumption is valid for some neurons almost all of the time, and almost all neurons some of the time.

For constant membrane capacitance, equation (16) has the separation of variables solution

$$(21)\ V(x,t) = V_0 \exp(-x/LAMBDA - t/TAU)$$

where V_0 is the initial amplitude of the pulse where it was applied (here, the synapse). The "x" represents the distance traveled (here, the synapse-hillock separation), and the "t" represents the time elapsed. Notice the brevity of a PSP in general.

How much a single PSP increases the hillock voltage by is clearly represented by equation (21). A series of PSPs arriving at synapse j would increase the hillock voltage by the product of volts per cycle and cycles per second summed over all cycles:

$$(22)\quad \left(\frac{\partial V}{\partial PSP}\right)_j \dot{PSP}_j = \sum_{i=1}^{n_j} V_{0_{ij}} \exp\left(-X_{eff_j}/LAMBDA - \Delta t_{ij}/TAU\right)$$

Given stationarity,

$$(23)\quad \left(\frac{\partial V}{\partial PSP}\right)_j \dot{PSP}_j = V_{0_{ij}} \sum_{i=1}^{n_j} \exp\left(-X_{eff_j}/LAMBDA - \Delta t_{ij}/TAU\right)$$

If toa_{ij} stands for the time of arrival of post-synaptic potential i of synapse j, then

$$(24)\quad \dot{PSP}_{ij} = \dot{PSP}_j\,(toa_{ij})$$

Thus, inserting (23) and (24) into (15) and writing everything in one line,

$$(25)\quad \dot{AP} \simeq \left(V_{cr} - V_{mh0}\right)^{-1} \sum_{j=1}^{m} \left\{ V_{0_j} \sum_{i=1}^{n_j} \dot{PSP}_{ij} \exp\left(-X_{eff_j}/LAMBDA - \Delta t_{ij}\right)\right\} \text{spikes}$$

where m = number of synapses

n_j = total PSPs received at synapse j

$X_{eff\,j}$ = equivalent distance of synapse j from the hillock

and $\Delta t_{ij} = t - toa_{ij}$ where toa_{ij} is the time of arrival of PSP i at synapse j

From equation (6),

$$(26)\quad d\widetilde{PSP}_j = \dot{PSP}_j\,dt$$

$$(27)\quad \int d\widetilde{PSP}_j = PSP_j - PSP_{j_0} = PSP_j = \int \dot{PSP}_j\,dt$$

If, then, i identifies a PSP (first PSP: i = 1; second PSP: i = 2; etc.,),

$$(28)\quad \int_0^{toa_{ij}} \dot{PSP}_j\,(t)dt = i$$

Thus toa_{ij} may be found from (28). Two conditions must be imposed, however, to eliminate the possibility of multiple solutions:

$$(29)\quad PSP_j\,(t) \geq 0 \text{ for all t}$$

and

$$(30)\quad toa_{ij} \geq 0 \text{ for all ij}$$

Equations (25), (28), (29), and (30) constitute the solution sought, given the three basic assumptions.

ACKNOWLEDGEMENTS

I would like to thank Drs. Eaton (entomology) and Roper (physics) of Virginia Tech and Drs. Tipton (biology) and Moran (mathematics) of Radford University in addition to Mr. Steve Rowland of Tech who is an engineering undergraduate student.

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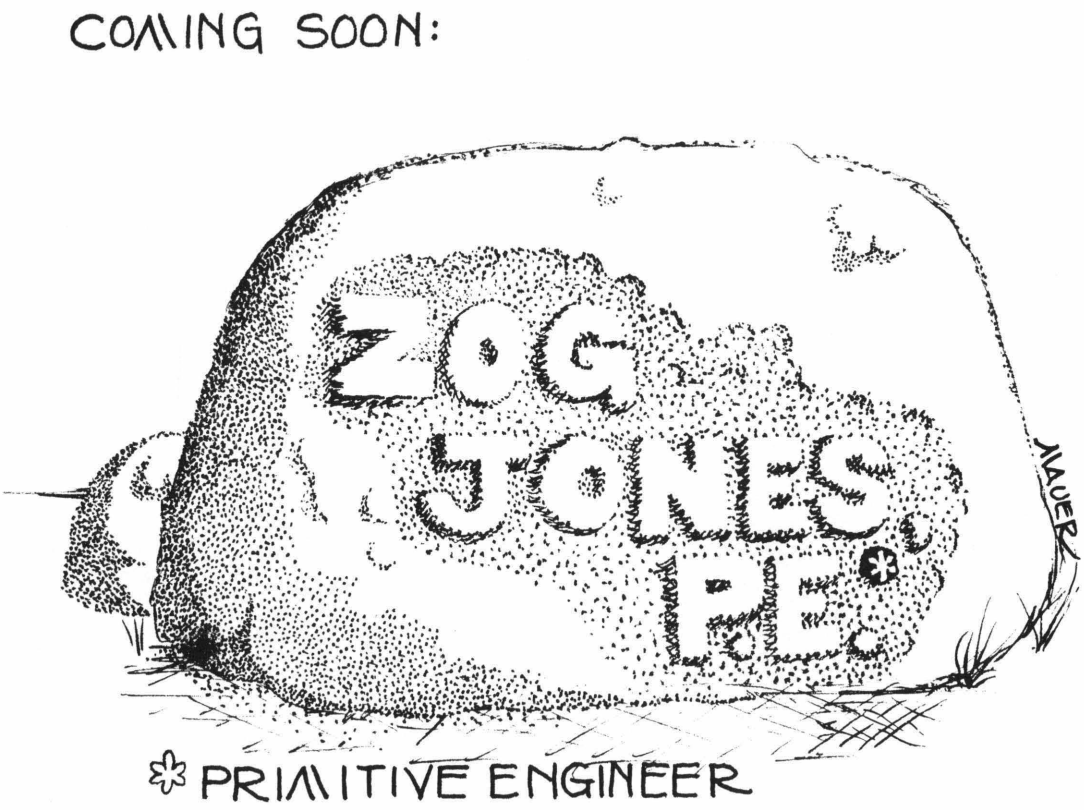
by Mark Moran

Illustrations by T Mullins



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The ten engineering departments will also be represented at EXPO. The departments will set up displays through their respective honor and professional societies. In addition, the undergraduate and graduate cooperative education office will be on hand to answer questions and assist students. A new addition to EXPO is the Management System Laboratories, one of the largest research groups at Tech.

In the past, EXPO has enjoyed great success. Both students and companies have benefitted from the experience. Continuing this tradition, we expect more companies of diverse sizes and types to attend this year.

The Student Engineers' Council extends an invitation to all students to attend one of the largest fall events on the Virginia Tech campus. You will find EXPO '84 to be a rewarding experience whether you are a freshman, a graduating senior, or a graduate student.

by Mark Traband & Nathnael Gebreyes

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Engineers' Forum

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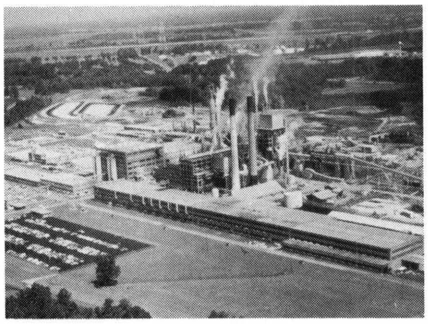

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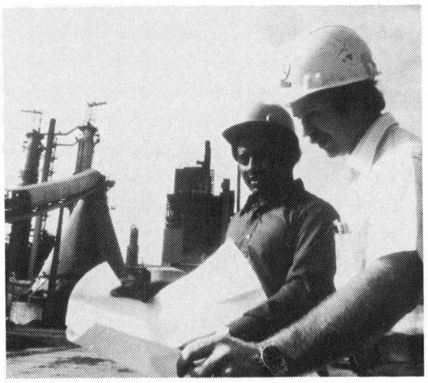

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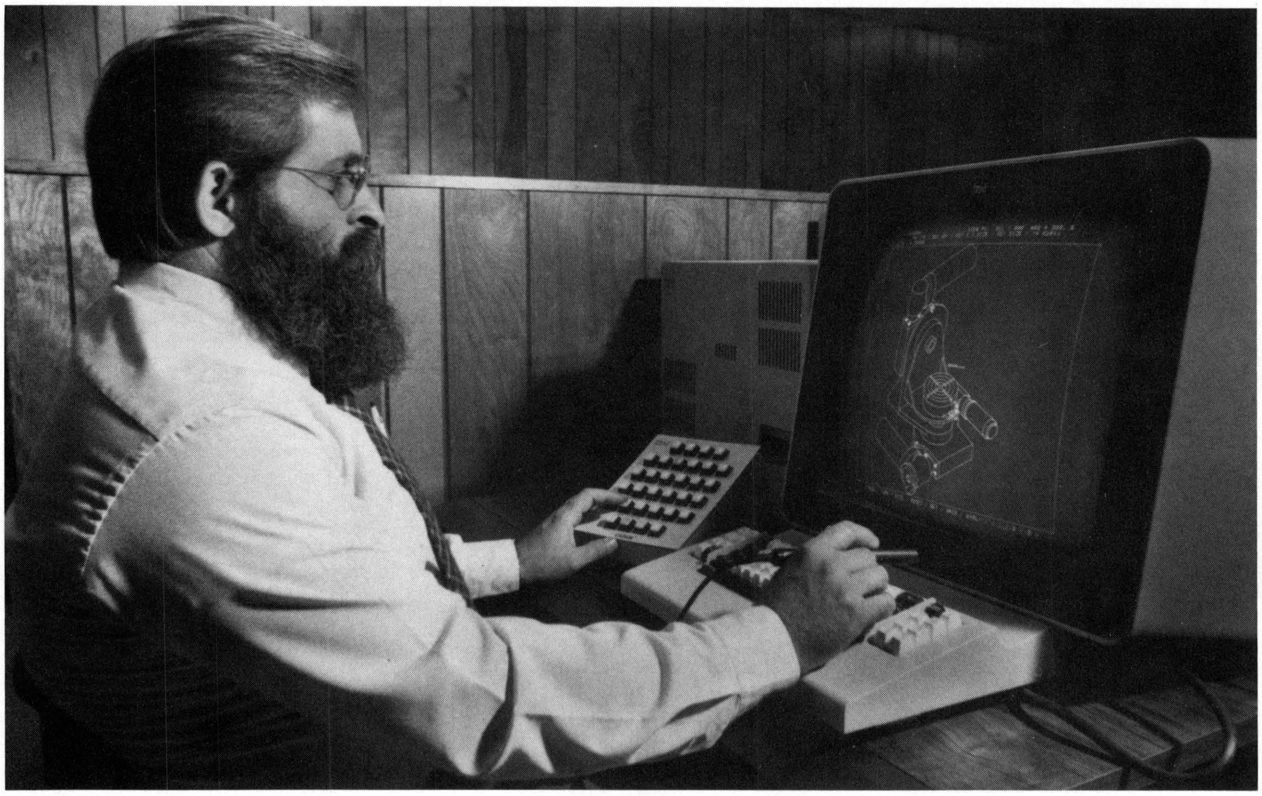

K. Bible

Engineering Design Enters the Computer Age

by Karen Soos

As any bright young engineer knows, the computer is the most useful tool since the pencil; besides performing the mundane, it can also do the impressive. One "impressive" program currently being developed at Virginia Tech is CAD/CAM–Computer Aided Design/Computer Aided Manufacturing.

For several years now, the Mechanical Engineering Department has run a similar program for upperclassmen called CAED, or Computer Assisted Engineering Design. With CAED, the computer is used to perform engineering analyses in designing parts. It frequently uses computer graphics, although it generally gives numerical, not graphical, results. CAED is used in nine upper-level ME courses, including all of the design courses: ME 3010, 3060, 3090, 3200, 4090, 4100, 4361, 4380, and 4390. Virginia Tech is a national leader in this field, having been one of the first universities to use CAED as a major part of an engineering curriculum; this role was emphasized by IBM's recent $40 million computer-system donation to Tech and nineteen other schools.

Consisting of the IBM 4341 processor system, storage devices, and graphics terminals, it is being largely used by the developing CAD program. More specialized than CAED, CAD uses interactive graphics, in addition to engineering analysis and design techniques, to graphically design a system. As a result, the designer can obtain an optimal design, and is saved the labor of the repetitive calculations. CAD allows the engineer to condense the data, interpret it graphically, modify it as needed, and generate new solutions. The instantaneous graphical feedback leads to better results.

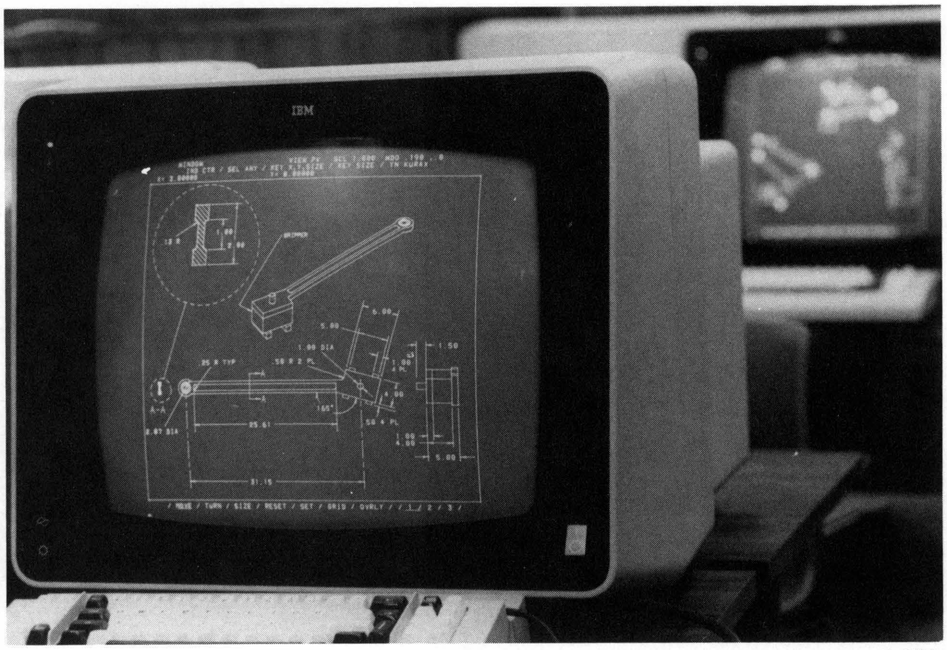
The CAD process involves several steps. The largest part is the drafting, where a light pen or digitizer is used to enter the geomtrical characteristics of the design object. As Dr. Arvid Myklebust, director of the Virginia Tech CAD/CAM lab says, "It's quite an involved process, but to do it by hand with a pencil is far more complicated, and in addition, you've got nothing but a pencil drawing when you're through. Here we have true numerical data describing the machine." Once entered, analyzed, and modified so that all requirements are met, those characteristices never have to be reentered. The geometry and analytical results are all stored in a data base, so that they can be called up immediately, in all detail. Furthermore, most installations like the Tech lab have libraries of standard parts so that only customized parts need to be individually entered.

Thus the CAD/CAM software system, unlike CAED, is an integrated system, allowing the same data to be used for many separate design operations. In addition, the design data can be sent to a manufacturing system, software that specifies what machine operations are needed; this in turn sends it to the machine tools. Little human intervention is needed between the design and manufacturing phases.

This process takes a highly complex software system. According to Dr. Myklebust, the software used in the lab has about one *million* lines of source code. Called CADAM–Computer Assisted Design and Manufacturing System–it was created by Lockheed nineteen years ago. This summer, Dr. Myklebust, who has been involved in CAD for about fifteen years, will add to it his own software for mechanism design. His software will be used to analyze and animate a mechanism using automatically generated shapes to show motion in three-dimensions. The results are passed on to CADAM for the final design and to specify manufacturing instructions.

He explained, "Just as we envision a system operating in our minds when we do creative design, the engineer will be able to see, using this software, a system go through its paces without having to sit down and spend days entering the geometry."

Using this system, the first prototype is the last prototype. All the analysis, testing, and evaluation are completed before the design even reaches the shop. As Lockheed's pioneering development would indicate, the aircraft companies have been in the forefront of CAD/CAM technology. The Boeing 767 was developed largely with these techniques.

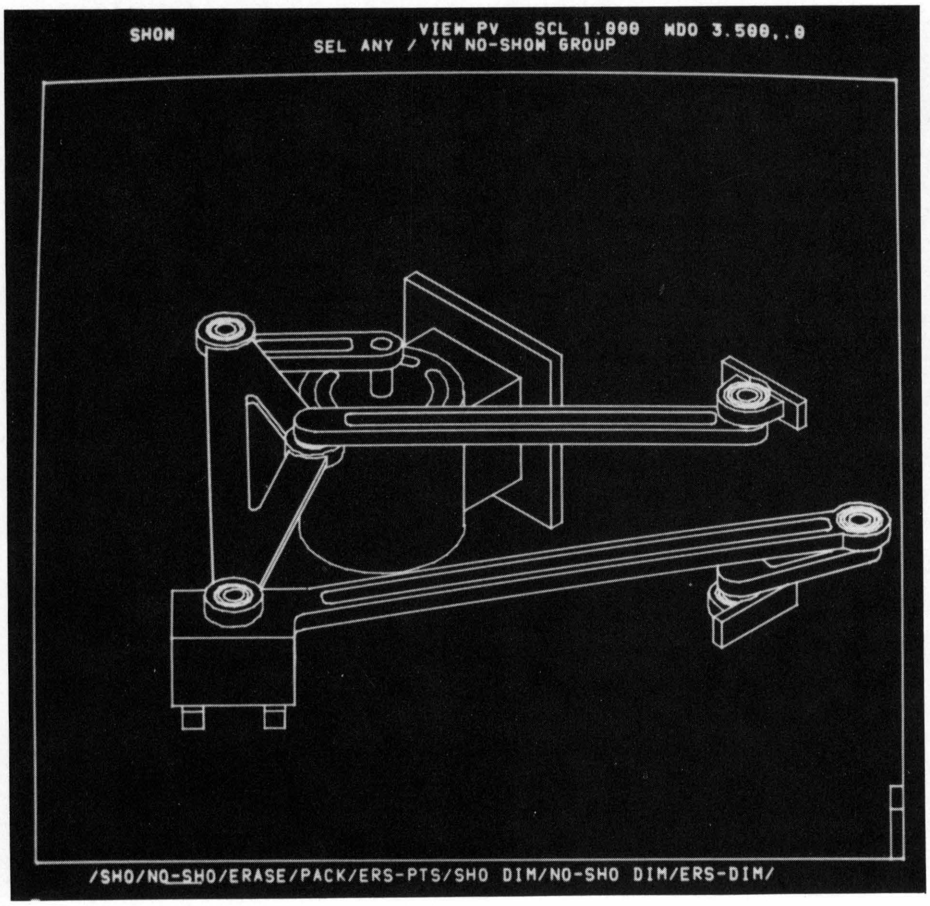


K. Bible

One project that Dr. Myklebust is currently working on is a three-axis rotation table, or robotic positioning device. His students developed the device's geometric design, and made various assembly drawings and views of it. They entered data and dimensions with a light pen, projected viewlines to make an isometric projection, and modified the parts to meet various requirements. Later Dr. Myklebust will design the computer controlled prototype for the patented device. By entering data via the keyboard, his program will allow a part placed on the device to be positioned anywhere in space about a point.

CAD/CAM at Virginia Tech is open to all fields related to it, such as IEOR. Since IBM stipulated that the donated system must be used for research eighty percent of the time, CAD courses are offered primarily on the graduate level. Dr. Myklebust, however, does teach ME 4980 which is open to senior ME's, and is designed to acquaint them with the system and teach them about commercial CAD/CAM methods.

While presently found only as an ME course, the program may soon expand to other branches of engineering. Though the classes are small now, Dr. Myklebust expects them to grow as new equipment is added and as interest in the field develops. He foresees that "all the activities that we do in Mechanical Engineering, and in other engineerings, will one day be included in a similar integrated, CAD/CAM system, so that the design engineer won't have to do anything but sit at a terminal and use it."



K. Bible

PICTURE QUIZ

Can you identify these familiar objects?

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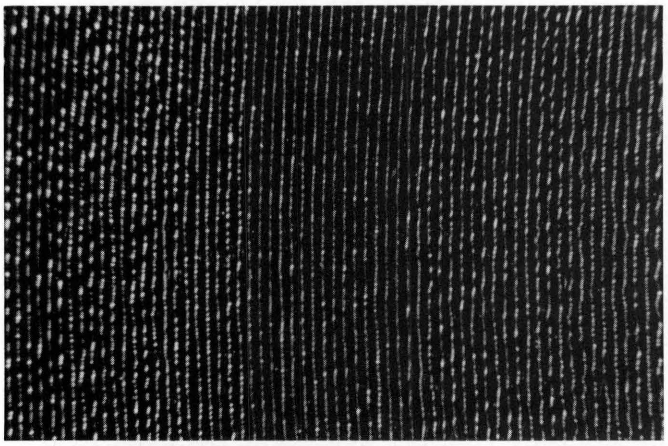

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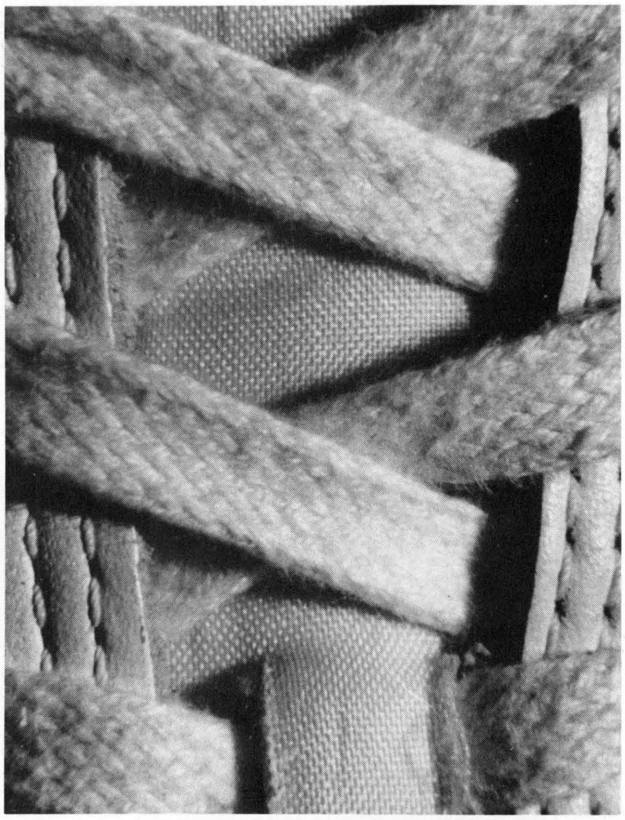

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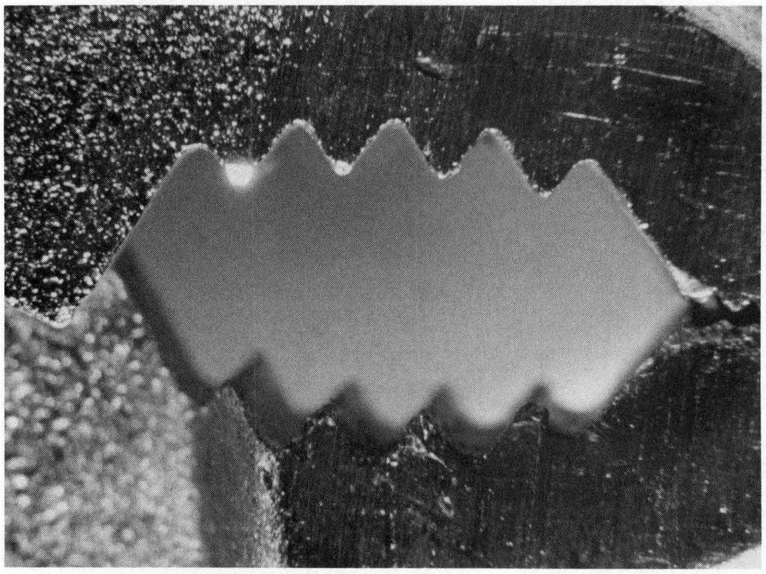

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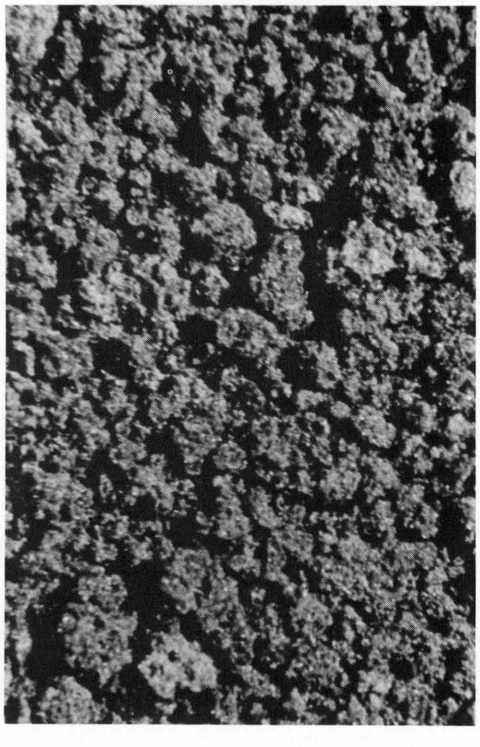

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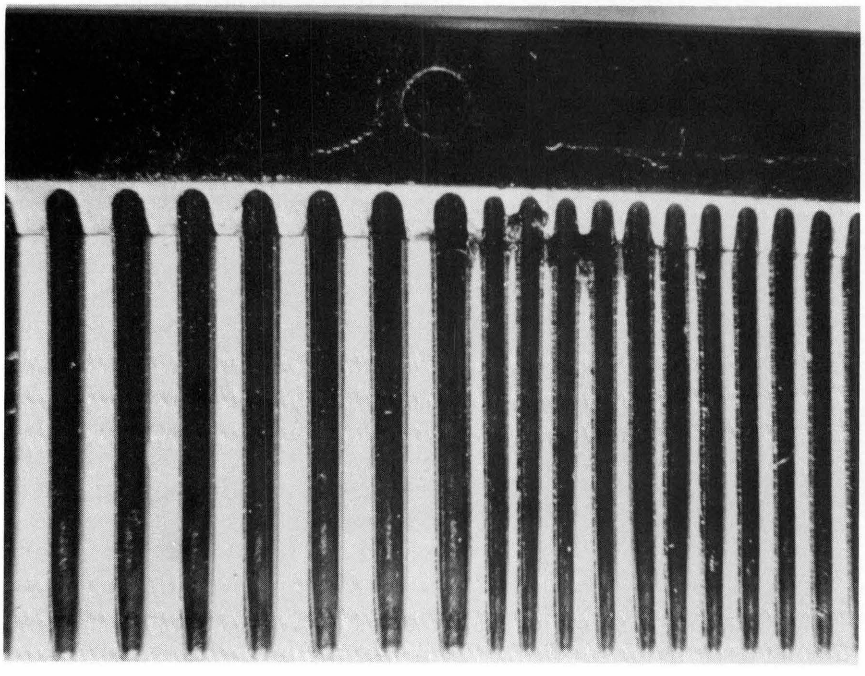

Answers: 1, record; 2, sneaker;
3 pliers; 4 coffee 5 comb

by Mark Hill

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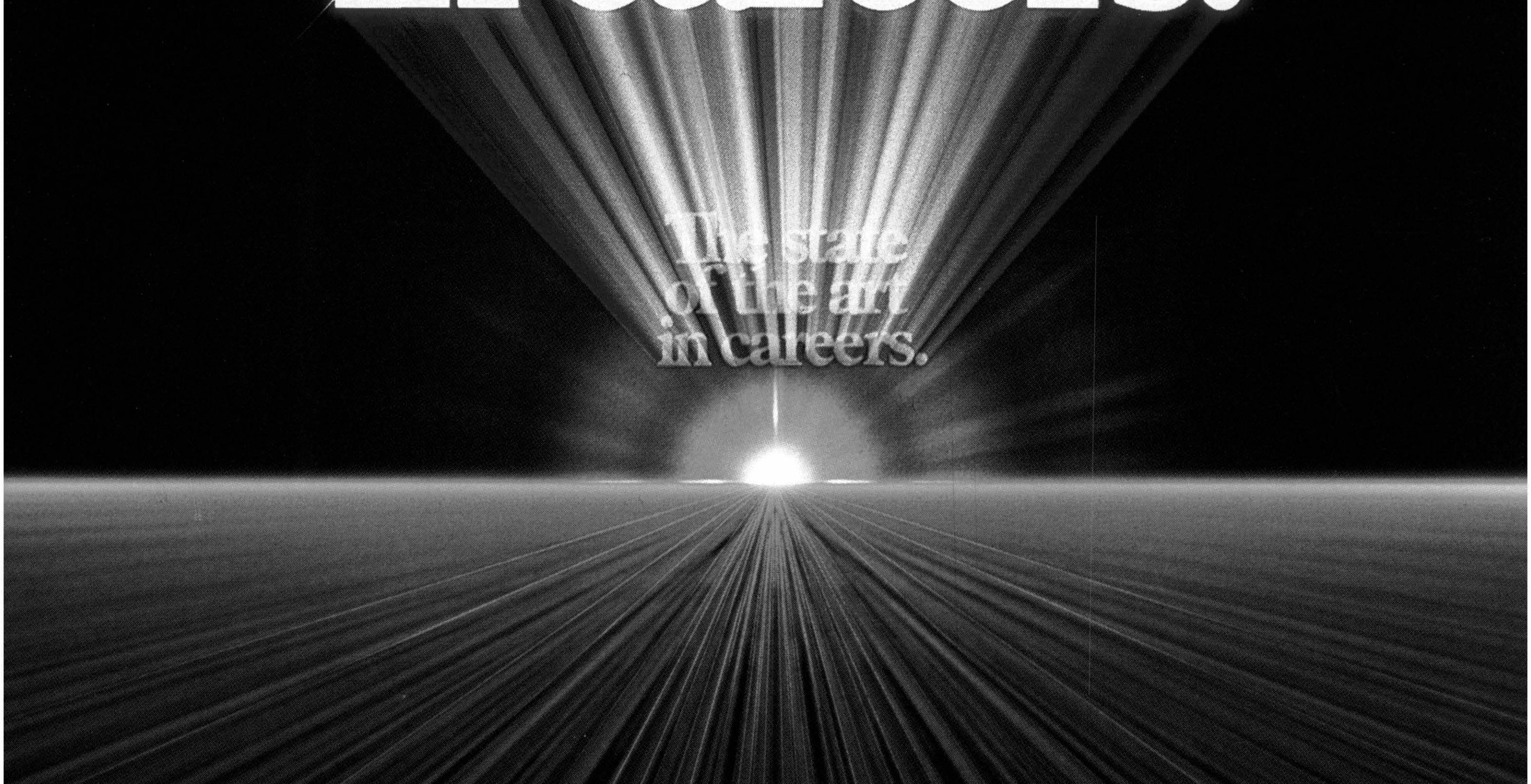

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