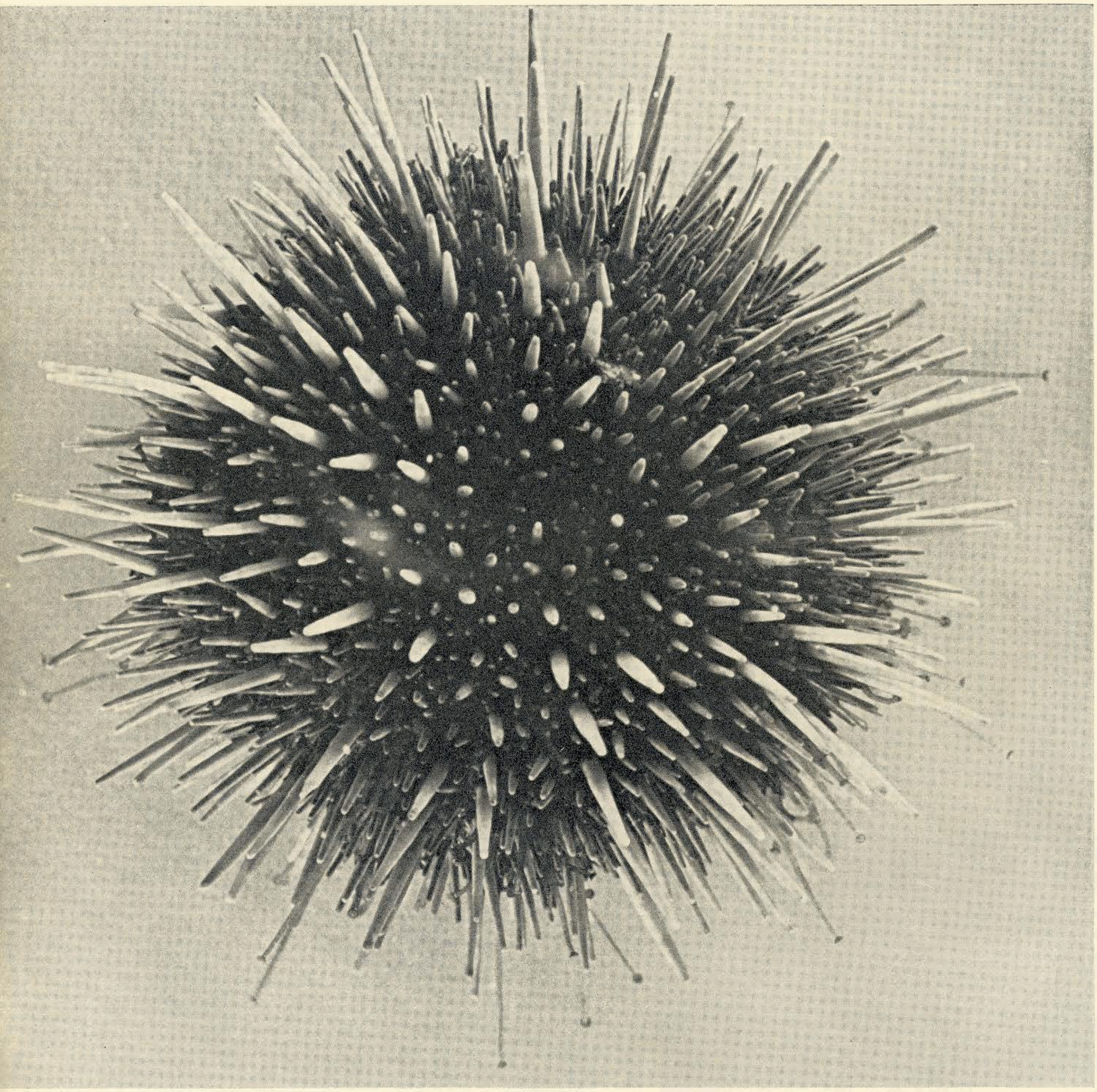
FEBRUARY 1967

ENGINEERING AND SCIENCE



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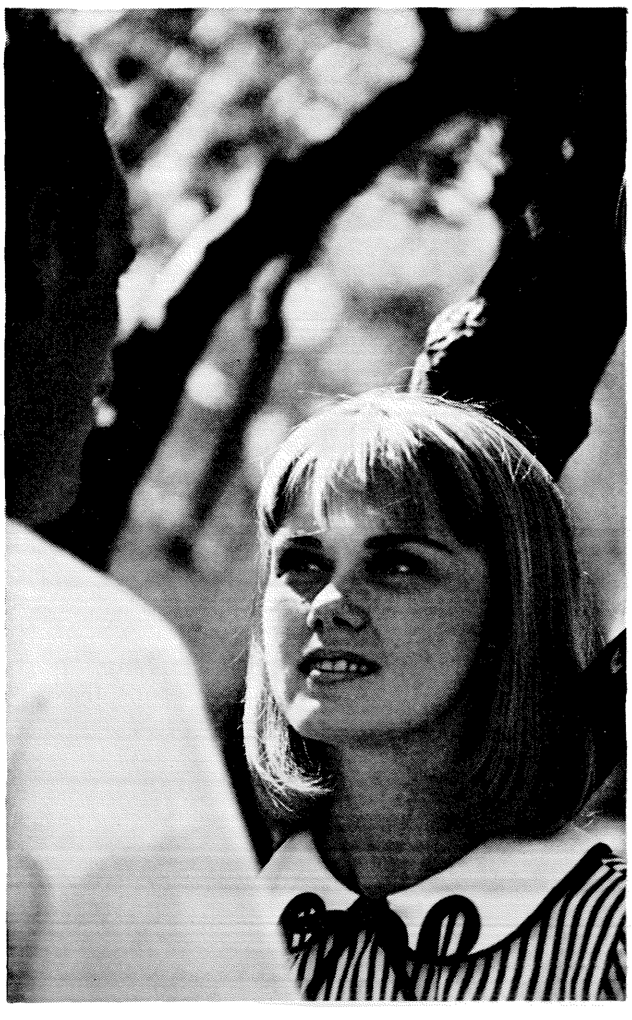

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ENGINEERING AND SCIENCE

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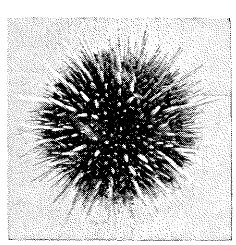
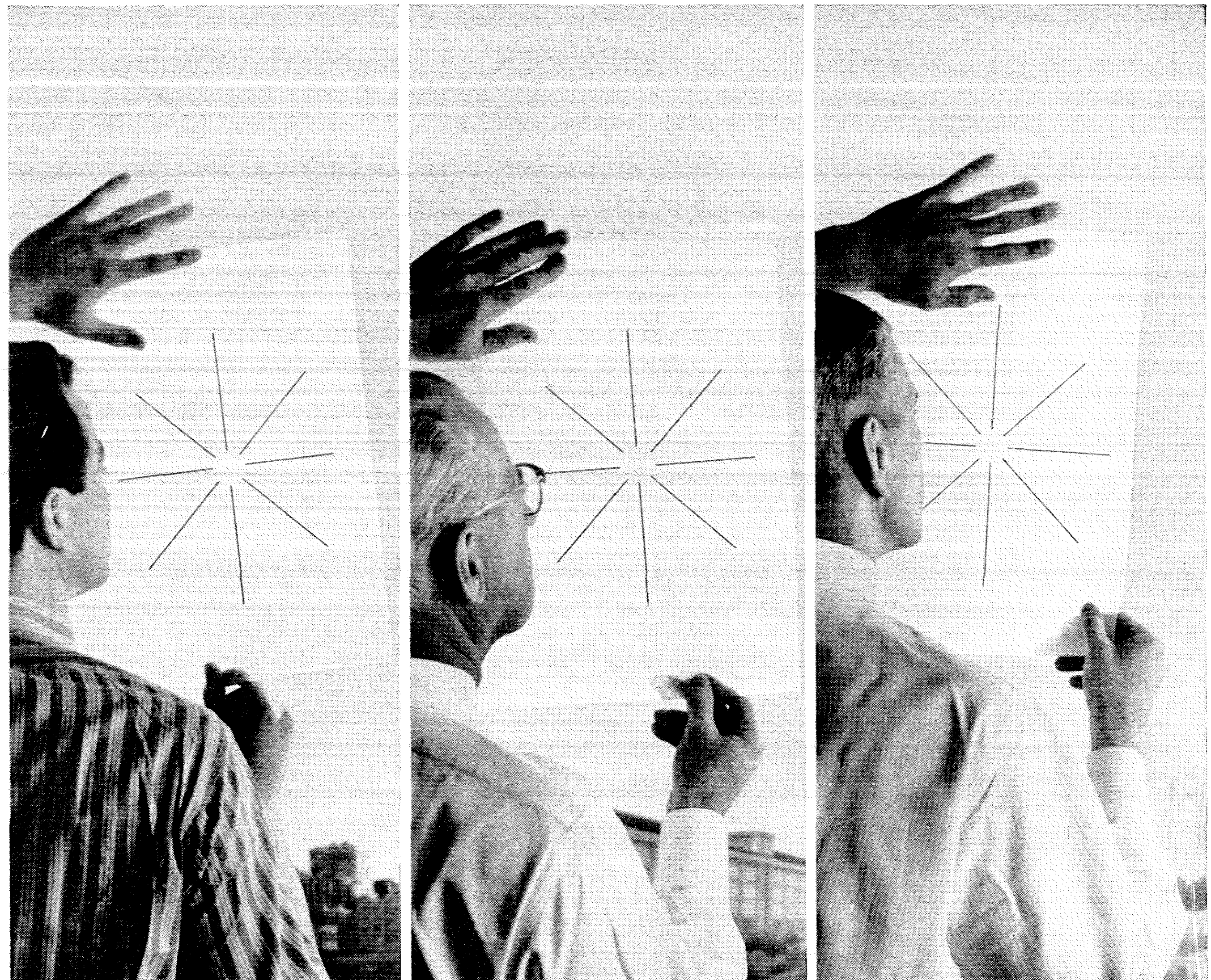


COVER

The *strongylocentrotus purpuratus* pictured on our cover is the sea animal most widely used in research by Caltech biologists. These purple sea urchins furnish most of the material used by Charles J. Brokaw, associate professor of biology at Caltech, in his current studies of swimming spermatozoa. In the article on page 12, "The Movement of Spermatozoa." Dr. Brokaw describes how the flagella (sperm tails) move to propel spermatozoa through water.



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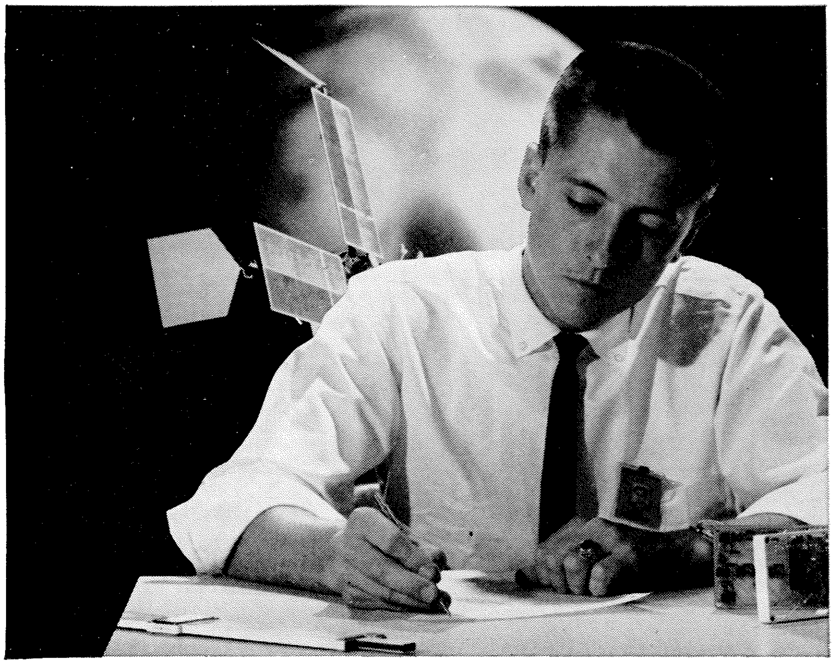

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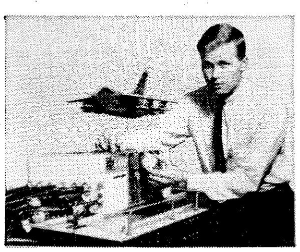

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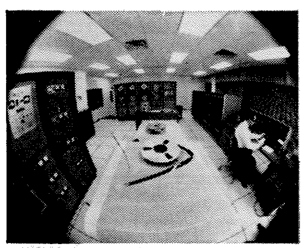

SIGNAL PROCESSING

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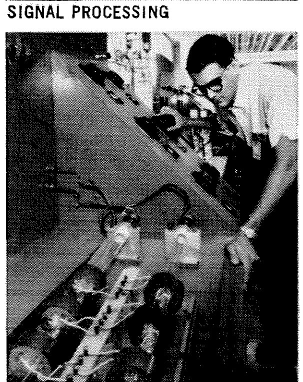
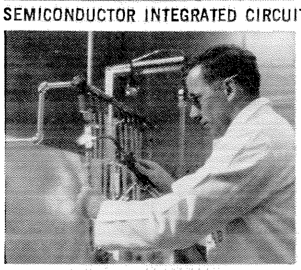


SEMICONDUCTOR MATERIALS



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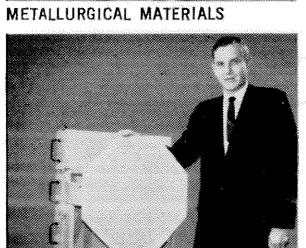

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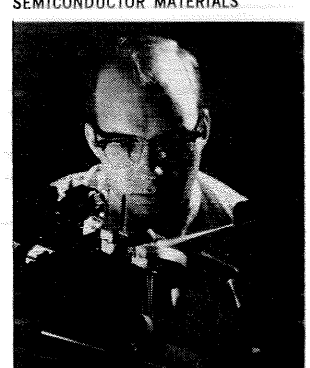

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ENGINEERING
AND SCIENCE
February 1967, Vol. XXX, No. 5

THE GOLDEN AGE — OR THE ICE AGE?

by Lee A. DuBridge

There is an old saying among scientists that when one is young he does research and teaches graduate courses; as he gets older, he gives up research and teaches elementary courses; when he gets still older, he gives up science and becomes a historian.

I do not have to explain to which category I belong. But I hasten to add that my ventures into the field of history are neither frequent nor profound. However, when a man has served 40 years or more in a profession, he simply cannot resist the temptation to look back and reflect on all the things that have happened since he was young.

Many people who look back as far in time as I do are pretty likely to say, "Those were the good old days; it's too bad things have changed." My position is the reverse: I believe things are a lot better today than they were 40 years ago, and they are going to be still better in the future. The golden age is not past; it is ahead.

I have, of course, spent all of my professional life in university work—so I must talk primarily about that realm of education. I have also spent my life in science, so I shall also talk principally about that field. However, I think science education represents a typical segment of all education.

When I began my graduate work in physics in 1922, there were scarcely a dozen universities in this country which awarded more than an occasional PhD in that field. Only 55 were awarded in the whole United States that year, compared to nearly 1,000 in 1966. Furthermore, in 1922 practically every new PhD who could possibly do so promptly took off for Europe to study for a year or two in Germany, England, or France. That is where the *real* physics was then being done.

In 1922 only one American had ever received a Nobel Prize in physics—A. A. Michelson in 1907. Europe, on the other hand, was alive with active physicists who were in the midst of the revolution in physics that took place between 1899 and 1930. Americans—with the exception of a handful who had studied in Europe—had almost no part in this great birth of modern physics, which included the discovery of x-rays, radioactivity, the electron, quantum theory, relativity, and all the rest.

Well, things have changed! Now American scientists receive a large share of the Nobel Prizes; they are invited to go for lecture tours in Europe. And the opportunities available to the young American scientists to work and study here at home make him the envy of the world. The famous, or infamous,

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This article has been adapted from an address given by President DuBridge at the 51st Annual Convention of the National Association of Secondary School Principals held in Dallas, Texas, on February 27, 1967.

"brain drain" exists today precisely because of this.

However, you might say, at least the American scientist of the 1920's did teaching instead of research—indeed he did! Twenty class hours a week—plus preparation, quizzes, and lab reports. If he did any research at all, it was in the evening and on Saturday and Sunday afternoons. And on a budget of a few hundred dollars a year!

Did we do a good job of teaching then? On the whole, we did not. With very little time to keep up with what was going on in the exploding world of physics abroad, most of us plugged away teaching from the textbooks that had been written 20 or 30 years before—or recently rewritten by those who hadn't learned much in the meantime either.

Those were the good old days, as I saw them. And I don't want to go back.

Winds of change

Fortunately, about 1922 the winds of change began to blow. During the next 18 years American science came of age—just in time to make a spectacular contribution to shortening and winning World War II.

What has happened since World War II is familiar history. Today not a half-dozen, but over a half-hundred American universities are in the forefront in teaching and research in science. Another threescore are doing a good job and are getting better. The American university student now learns as a freshman what modern science is all about. As a senior, he is at the frontiers of his field, reading this week's scientific journals and reports, often doing research himself. His teachers know what they are talking about, for they are active scholars too. The teacher who is using even last year's lecture notes will probably be nailed to the wall by his own students.

About ten years ago, something new began to happen. These same university scholars—who, according to the newspapers, were too busy doing research to bother with teaching—began to worry about the obsolete science being taught in the high schools. And they began doing something about it. In collaboration with the best high school science teachers, they began to revolutionize high school science courses. Soon better prepared high school graduates began flooding the better colleges and universities, who soon found they had to revolutionize—again—their college-level courses. And now the elementary schools are improving their courses too. The spiral is on the way up!

But lest you get the impression that I think the golden age is already here, let me tell you about the darker side of the picture. Yes, in the *better* high schools and in the *better* colleges and universities a new era has dawned. But not all schools and colleges are the *better* ones. Most, indeed, are not. And in many a school and college the picture is a depressing one. There are understandable reasons, of course. The schools in the slum and ghetto areas find the going almost impossibly tough. The new science curricula find no place there. The hundreds of small, impoverished colleges also cannot attract well-trained teachers and cannot afford modern equipment; hence they do not attract the well-prepared students. They, too, are often caught in a vicious circle.

How that vicious circle can be broken I do not know. Educators are working on it. Everyone knows the importance of good education today. Not everyone knew that 40 or 50 years ago. Today we are all aware of our problems; we are no longer smugly satisfied with the status quo. We have seen that in a remarkably short time the upper third or half of our educational system—both schools and colleges—can be vastly improved. Lifting the lower half will be harder, but we are on the move and we shall surely make progress.

The progress in science during these postwar years has to a large extent depended on a new factor which has entered the picture: the government support of university research and of graduate education, plus the support of high school curriculum improvement and of teacher training.

Need for federal funds

There can be no doubt that government funds have vastly benefited American education in science. But that headaches have arisen, there can be no doubt either. The headaches stem from many sources. Rapidly rising college enrollments have increased faster than either local or federal funds or trained teachers. In many areas we have fallen behind in adequate classrooms and laboratories. Federal funds have helped in science, but not in other areas. Political logrolling tends to divert scarce federal research funds from institutions which can make good use of them to those which can not. Whether we like it or not, graduate teaching and research can not be equally well done in *every* Congressional district. Exceptional people and exceptional facilities are still to be found only in 50 to 75 key universities; they do not exist—*can* not exist—in every small college. Research funds are intended to foster the growth and excellence of American science; they are not benefactions to institutions. Nor should they be converted into handouts for everyone.

Right now a real crisis exists in American science.

A freeze, and even a reduction, in science and education appropriations appears imminent—just at a time when substantial additional funds are required. More rather than less money is needed to meet Congressional demands for more "geographic distribution" of science funds.

Yet the new federal budget is not meeting these needs. Many basic research and graduate fellowship budgets are being slashed. Funds for new projects will be hard to find, and promising young teachers and investigators will be frozen out. A real crisis in the progress of science and science education is indeed in the offing. Our golden age is being thus delayed. We may have an ice age instead!

I believe that our educational system is all of one piece. The problems of any one segment pose problems for all. The better students go on to colleges and universities; new teachers must be supplied there; the health of American life and culture centers there. Conversely, higher education benefits from the successes of our elementary and secondary schools; and we suffer, too, from its shortcomings.

In this year 1967 all educators face a common overriding problem, posed by the fact that our nation and the whole world are changing so rapidly. A century ago a student who was lucky enough to acquire an education could be comfortable in the feeling that he now knew enough to last him all his life. The world in which he was living was a moderately static world. At least it was changing so slowly that what he had learned would probably not have be unlearned 10 or 20 years later. Nor would it be necessary someday to be reeducated to catch up with a knowledge explosion.

However, the conspicuous thing about the middle of the 20th century is that the world is changing at an enormously rapid rate. The facts or the "answers" one learns in school today may be of little use in five or ten years. Even though what has been learned is still valid, lots of new things will have to be learned each year to understand and to live in our fast changing world.

This means that the whole purpose and philosophy of education now has to be changed, and, to a large extent, this is the change which has been going on in recent years. The emphasis is no longer on learning facts or answers but on learning the processes by which answers to new problems can be obtained. The question to be asked the student is not "What have you learned?" but "Have you learned *how* to learn?"

There are some educators who seem to feel that the explosion of knowledge means that more and more facts must be crammed into a student's mind every year and that the number of years during which the cramming process continues needs to be perpetually extended. Actually, the knowledge explosion has now made it quite impossible for any human being to grasp even a tiny fraction of the sum total of human knowledge. It has even made it impossible for any student to visualize the kind of knowledge he will need to be familiar with once he has left school. The task of the teacher today, therefore, is not to complete the learning process but to start it; not to instill a fixed body of knowledge, but to help the student understand the process of acquiring knowledge; not to encourage smugness in what the student has learned, but to stimulate curiosity about what he must learn in the future.

Now this necessary new attitude toward the educational process is not a trivial matter or one that can be accommodated by small adjustments. Even the quite major changes in the approaches to curricula that have been achieved in recent years do not fully meet this problem of changing attitudes.

Curiously enough, in our graduate schools where the learning process is most advanced, it is precisely this attitude that is well established. The young PhD knows full well that he has just begun a lifetime of learning. He knows enough to know that he knows little. It is often the high school or college student who seems to think he knows it all and that the learning process is now complete! Here is where new attitudes and new approaches are most necessary and, at the same time, most difficult. This is the challenge which teachers and administrators face most urgently. Because it is a large challenge, I say again that this is a poor time for our federal government to lose its interest in the promotion of high-quality education at every level. This is no time for an ice age.

Continuity in education

During the past 14 months, I have been engaged with others in a study which relates precisely to this problem of providing a mechanism whereby continuity in education can be encouraged from elementary grades on throughout life. There is one learning device which provides this continuity—the book. If a child learns to read, learns to love to read, learns to *learn* by reading, he can continue his learning process indefinitely. But in recent years another device for continued learning has been developed, namely, the television screen.

Most of us who view commercial television programs are not greatly impressed with this device as a great aid to education. But a new approach to television has recently been evolving, and it has tremendous untapped potentialities. It is noncommercial, or educational, television. I, and other members of the Carnegie Commission on Educational Television, have been addressing ourselves during the past year to the question: How can this marvelous technology of television be used as a real educational asset throughout school and throughout life? I should like to describe a few things which the Report of the Carnegie Commission says—and a few things which it does *not* say.

The Carnegie Report does not say that ETV is the panacea for all our educational problems. It does not say that the TV screen is about to replace the teacher, any more than a book replaces the teacher. What we do say is that television is a new and powerful technological instrument with very great educational potentialities which have hardly, as yet, even been tested. And we do say that for educational uses the television technology of tomorrow will surely be even more powerful, more sophisticated, and more flexible than it is today. We also say that the educators of America had better start giving more attention *today* to how this tool can best be utilized to improve our whole educational process and how it can lift the educational and cultural levels of all American people.

We found in our study that there now exist in the United States some 124 noncommercial or so-called "educational TV" broadcasting stations, capable, in principle, of reaching into two-thirds of the classrooms of the nation. Nearly all of the stations broadcast programs for classroom use. Some do little else. Most, however, also broadcast programs for home viewing.

Instructional television

We choose to call the broadcasts for classrooms or other instructional purposes "instructional television" (ITV) and the informational and cultural programs for home viewing "public television" (PTV). Thus, the noncommercial ETV system has both an ITV and a PTV function. Obviously, the two functions are intimately related, and there should be no sharp boundary between them. Both are broadly educational. Both can be a stimulus to learning. If a student learns to love books in the classroom, he can use them all his life. If he comes to see television as an aid to learning, he can use that all his life too, if we provide him with programs which teach and inspire him.

We found, however, that every single ETV station in the land is underequipped, understaffed, and underfinanced. Hence, none of them can render an adequate service. All 124 ETV stations together, plus National Educational Television (NET), have to get along on a total budget of $60 million a year. The commercial stations and networks spend $2 billion a year. The local, plus network, programs on an average commercial station represent an expenditure of $60,000 per station per week. The ETV station figure is only *one-eighth* of that. *Most educational television stations spend less in a whole year than a commercial network may spend on one single program.* This is a shocking situation!

Carnegie Commission goal

We have proposed that federal funds be used partially to close this gap. There will, no doubt, be endless debates in the public press, in the halls of Congress, in the executive branch of the government, on the particular structure and mechanisms which the Carnegie Commission has proposed to meet this goal. Let me restate the over-all goal of the Commission as stated in its report.

> "The Carnegie Commission has reached the conclusion that a well-financed and well-directed educational television system, substantially larger and far more pervasive and effective than that which now exists in the United States, must be brought into being if the full needs of the American public are to be served."

We recommend that the federal government, through the Department of Health, Education, and Welfare, should aid in extending and improving the educational television system, and actively sponsor new research on how television can be more effectively used in the classroom; how it can aid the learning process; how it can stimulate the desire to learn; how it can most effectively aid the teacher; how our educational system can most appropriately use the great power and flexibility of modern television technology.

The Commission further recommends that a new agency be created—a private, nonprofit corporation to be known as the "Corporation for Public Television"—and that this agency should be responsible for similar research into how television can be used as a powerful educational and cultural stimulus in the homes of the nation. We propose that this corporation expend substantial public funds in providing programming for the homes. We hope that the Corporation, in collaboration with the Department of Health, Education, and Welfare, will provide a mechanism and additional funding so that the schools and colleges of the nation, together with strong local stations in every community, can provide both the classrooms and the homes of the nation a new dimension in television, a new dimension in learning. This will mean a powerful tool with which the nation can help to meet the urgent problem of keeping the American people in tune with the world and in tune with life itself.

THE MOVEMENT OF SPERMATOZOA

by Charles J. Brokaw

A spermatozoon is a device for the transport of a package of DNA containing a male complement of the genetic information of a species. In most animals the delivery of this package to the egg depends in part on the active propulsion of the spermatozoon by undulations of its tail. The sperm tail is an example of the class of cell structures known as flagella or cilia, which are widely distributed among organisms wherever movements are required at the microscopic level. As far as we know, all cilia and flagella share basic mechanisms of motility. But as yet we know very little about these mechanisms.

The sea urchin spermatozoon is a favorite material for studying flagellar motion. Sea urchins are abundant near Caltech's Kerckhoff Marine Laboratory. They are "ripe" throughout most of the year and produce generous amounts of nearly pure spermatozoa. Their spermatozoa are simpler in structure than those of humans and other mammals, and their motion is somewhat simpler to study since the sperm flagellum bends almost entirely in one plane. The external and internal morphology of these spermatozoa—and other cells with flagella and cilia—has been intensively studied since the early 1950's, when the electron microscope became a widely available research tool. However, the detailed morphology of their movements has seldom been examined because very specialized techniques are required to record their movements.

The force causing forward propulsion of a spermatozoon is generated by the propagation of bending waves along the sperm flagellum, in much the same way that an eel or a snake propels itself by the passage of bends along its body. The bending waves originate near the head of the spermatozoon and are repeated regularly at frequencies of 30-40 beats per second. The waves pass backwards along the tail at speeds of the order of 1,000 microns per second and propel the spermatozoon forward at speeds of 150-200 microns per second. Since the sperm flagellum itself moves laterally through the water at speeds of about 400 microns per second (2,000 times its width per second) exposure times of 100 microseconds or less are required to obtain accurate photographs showing the form of the bending waves during movement. Because of its small size, very intense illumination is also required to photograph it. To study how the shape of the flagellum changes with time as it generates its bending waves, photographs taken at intervals of a few milliseconds are desirable. Only a few electronic flash illumination systems have been built that meet these particular requirements.

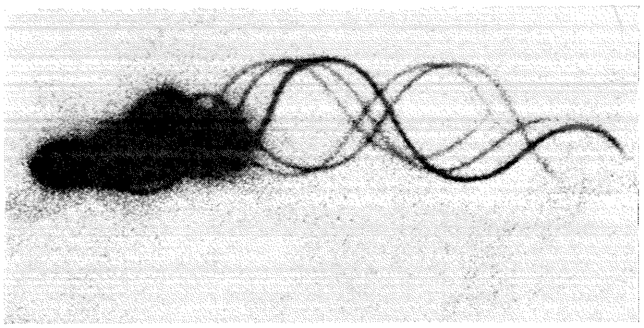
In 1955 Sir James Gray, professor of zoology at Cambridge University, published a description of the movements of sea urchin spermatozoa, based on photographs taken with exposures of 2 milliseconds duration. He concluded that the shapes of the bent sperm tails shown on his photographs could be closely matched by sine waves. This conclusion formed the basis for most theorizing about flagellar movement for the next ten years. The relationship between the bending waves and the forward swimming of the spermatozoon was developed mathematically, and mechanisms for generating bending waves were proposed on the assumption that the waves were similar to the familiar sinusoidal vibrations of an elastic rod, modified to include internal amplification to prevent a decrease in amplitude as the sinusoidal waves passed along the flagellum.

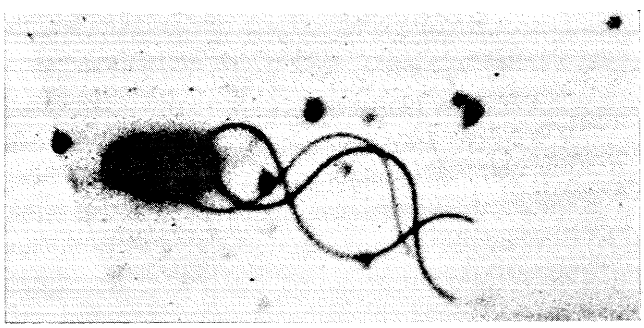
My own interest in flagellar movement dates back to the period from 1955 to 1958, which I spent as a graduate student in Sir James Gray's depart-

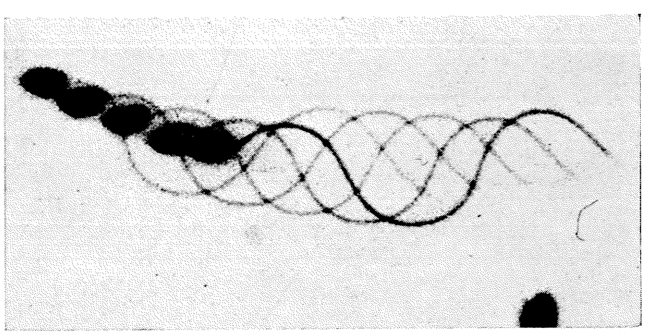
continued on page 14

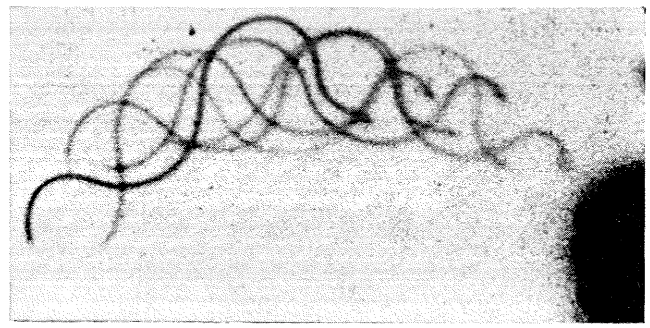
CHARLES J. BROKAW, '55, *associate professor of biology at Caltech, is studying how spermatozoa make the movements which enable them to swim. Much of this work is carried on at Caltech's Kerckhoff Marine Laboratory at Corona del Mar, where the marine animals used for these studies are abundant. Dr. Brokaw has just been awarded a three-year grant from the United States Public Health Service for the continuation of this work.*

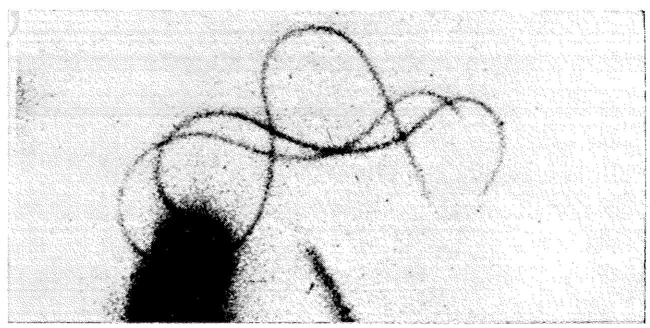
This series of pictures (reproduced here as negative prints at 1600-fold magnification) was taken to obtain information about the changes in the shape of the tail of a swimming spermatozoon. The photographs are made using dark-field illumination and a sequence of flashes, so that each photograph is a multiple exposure showing one spermatozoon in several positions. The first flash in the sequence can usually be identified because it is more intense than the subsequent flashes.

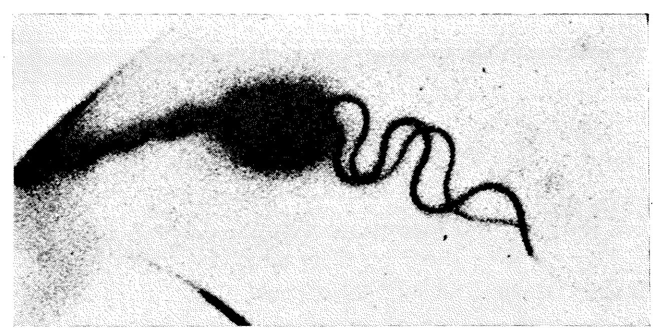












1. A swimming spermatozoon of a sea urchin photographed at 50 flashes per second.

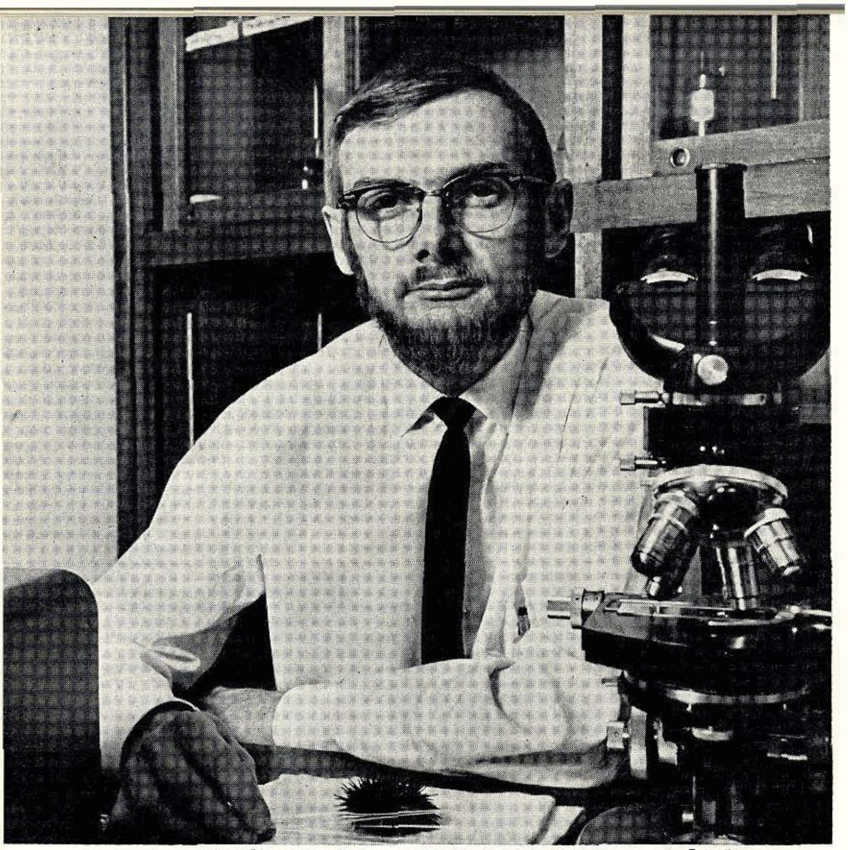
2. A swimming spermatozoon of an annelid worm photographed at 50 flashes per second.

3. Spermatozoon of a tunicate—at 40 flashes per second, only slightly faster than the beat frequency of the spermatozoon, showing the approximate forward progress made during each beat cycle.

4. The movements of a sea urchin spermatozoon after the head and midpiece have been removed by shearing a sperm suspension. The movements last for only a few seconds but prove that all the machinery needed to generate bending is located in the tail.

5. A spermatozoon which has been inactivated with 50 percent glycerol and then reactivated with ATP.

6. One type of movement obtained when spermatozoa are swimming in a solution containing methyl cellulose to increase the viscosity. Under these conditions the flagellum can form much sharper bends than in normal swimming.



Charles Brokaw, associate professor of biology.

ment at Cambridge. After some attempts to study the biochemistry of isolated flagella and to correlate this with movement, I realized that the available information on the movement of flagella was inadequate. In 1963, using a new flash illuminator built at Caltech, I obtained photographs of the morphology of moving spermatozoa which suggested that Gray's earlier conclusion was incorrect.

These photographs, having considerably greater resolution, showed that the shape of the bent flagellum did not match a sine wave. Instead, it contained regions that appeared to be bent into circular arcs. These bent regions, alternating in direction along the flagellum, appeared to be separated by shorter regions where the flagellum remained straight. Although the difference between such a wave and a sine wave is small—easily hidden by the limited resolution of Gray's original photographs—it is not completely trivial. It makes possible a simpler and more complete analysis of the relationship between the bending waves and the forward swimming of the spermatozoon. More significantly, it suggests a simple model for the generation of bending waves in all types of cilia and flagella. This model could never have been seriously considered as long as it was believed that the waves had to be sine waves.

According to this new model, each bend on the flagellum forms an arc of a circle within which the curvature of the flagellum remains constant. At any moment, bending is occurring only at the leading edge of the bend, where the shape of the flagellum changes rather abruptly from straight to curved. Unbending is occurring only at the trailing edge of each bend. These transition regions, which mark the ends of each bend at any given moment, are the only points where the flagellum is actively doing anything. As the flagellum bends at one end and unbends at the other end of the bend, the bend itself moves along the flagellum. Each pair of transition regions passing along the flagellum causes a propagated bend, and two opposed pairs of transitions form a complete bending wave.

This new way of thinking about the bending waves of flagella allows us to see more clearly the questions which must be answered before we can understand how the internal mechanisms of the flagellum generate its movements:

1. What are the internal structural correlates of the bent and straight states of the flagellum? How is the transition between these two states brought about?

2. What sort of information transmission is responsible for the point-to-point propagation of transitions along the flagellum?

3. How is the properly timed sequence of transitions initiated at the head end of the flagellum?

These are the questions which our research is now trying to answer.

The smallness in the size of the flagellum has so far prevented us from knowing whether bending is causally correlated with the contraction of subunits, analogous to muscles, on each side of the flagellum. We do know, however, that if the flagellar membrane and the energy-converting systems of the sperm midpiece are destroyed by treatment with 50 percent glycerol, the movements of the

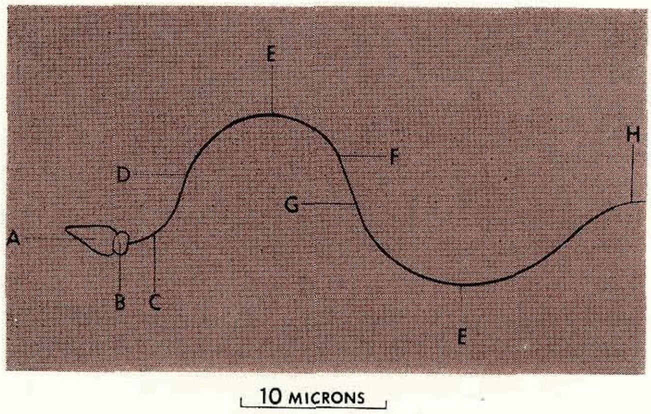


Diagram of a sea urchin spermatozoon. A. Head, containing genetic information and devices for entering the egg. B. Midpiece, containing a store of fuel and the enzymatic machinery needed to convert it to a usable form—ATP—supplied to the tail. C. Tail, or flagellum—its bending movements propel the spermatozoon. D. Unbending point. E. Bent region. F. Bending point. G. Straight region. H. Terminal piece; significance unknown.

spermatozoa can be reactivated by adenosine triphosphate (ATP). ATP is the biochemical fuel used by muscles and by most other cellular systems that produce work.

I am now trying to measure how much ATP is used at each transition region as it moves along the flagellum. Some results suggest that each bending transition may involve the use of just one molecule of ATP by each of the enzyme molecules involved. The next step will be to try to measure the number of molecules used under conditions where more extreme bending occurs, such as may happen when spermatozoa are swimming in solutions with much greater than normal viscosity.

Because flagella are so small, most speculations made about their internal mechanisms involve very simple solutions. The simplest way to transmit information from point to point along the flagellum, to turn on a transition at the next point, might be to use as a signal the structural strains which will inevitably arise near the transition between a bent region and a straight region. The details of this idea have been worked out, and we are now trying to test it experimentally.

One experimental approach to this question, which is being pursued by Stuart Goldstein, a graduate student in biology working at the Kerckhoff marine lab, is the use of a laser microbeam to damage small portions of the spermatozoon. For these experiments a redesigned flash illuminator for photographing the spermatozoa is being built, which can be synchronized with the laser discharge and the movement of the target spermatozoon.

These experiments should allow us to discriminate between the characteristics of the bending, unbending, and information transmission processes and to distinguish the properties of a special region near the base of the flagellum that may be responsible for the initiation of bending and unbending transitions.

The flagellum is an example of what may be termed an "oligomacromolecular" system. The answers to our questions about its mechanisms may lie tantalizingly between the cellular level, at which techniques such as optical and electron microscopy can give clear results, and the molecular level, at which highly developed techniques exist for the biochemical study of macromolecules and their interactions with other molecules in solution. The unanswered questions pose challenging problems, which become even more absorbing when one watches spermatozoa swimming under the microscope and sees the beauty of the regular and seemingly effortless rhythm of their movements which photographs cannot capture.

CONVERSING IN CITRAN

A new computer language designed specifically to be easy to learn and to allow direct conversations with the machine has been developed at Caltech by Stephen H. Caine, head of programming systems at Booth Computing Center, and Richard H. Bigelow, graduate student in engineering science.

The new system, named CITRAN (a combination of the initials of California Institute of Technology and the first four letters of the word *translator*), has proved to be remarkably successful in both of these objectives. Caltech students have been able to learn CITRAN and put it to work on the computer desk consoles in about *one-tenth* the time it took under the previous system. Within two hours they are able to read the 36-page instructional manual and to begin using the computer system.

CITRAN was first introduced last fall to freshmen in their physics and chemistry laboratory courses. Students have the use of 25 desk console computers, 15 of which are in laboratories throughout the campus and 10 in the computing center. All 25 are hooked up to an IBM system/360 Model 50 computer and can be used simultaneously.

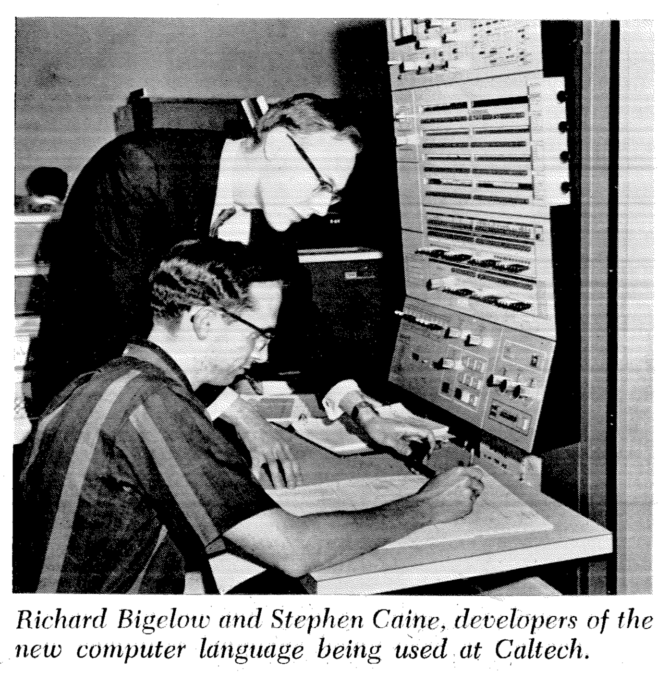
CITRAN users can communicate with the computer on the spot and are therefore able to immediately correct any error in the direction of their programming. The more complicated, classical methods require a complete specification of the problem to be punched on cards before it can be submitted to the computer. The problem must then await its turn among many others to be fed to the computer. Much later the user may discover that a single inconsistent detail makes necessary a complete revision of his programming.

Taking the general idea of JOSS, a system developed recently at RAND Corp. of Santa Monica, CITRAN's innovators worked out the new language in six months, with the support of National Science Foundation funds and International Business Machines, Inc., equipment.

The computer console keyboard used under the CITRAN system resembles a standard electric typewriter in letter and figure placement. The language includes such commonly recognizable symbols as – for *subtract* and = for *equals*. Special symbols and abbreviations are used, such as an asterisk for *multiply* and *SQRT* for square root. If a student wishes to ask the computer to solve the problem—What is x times x and the square roots of x, if x equals 6, 11, 27, or 30?—he types: Type x*x, SQRT (x) FOR x = 6, 11, 27, 30. Less than a second after the order is typed the computer takes control of the console and produces the answers in neat form.

If the student omits something in his procedure, the computer interrupts him with a message such as *unrecognized name* or *x is undefined.* If he reaches a point where he doesn't know what to do next, he writes *HELP.* According to the CITRAN manual, *HELP* is recognized by the computer and will be given. "The type of help will vary from case to case," says the manual, "but will always be self-explanatory." Actually, all the computer now advises is for the student to see a consultant at the computing center. However, the CITRAN developers say they will eventually have the computer advising the students directly.

Novice students are not the only people using CITRAN. Graduate students, researchers, and faculty have found it a convenient system. With it they can test the correctness of an isolated part of a more complicated program before they proceed to set up for more time-consuming systems, such as FORTRAN. The great advantages of the use of the new language are the simplicity of the programming and the immediate adjustment of the programming it allows.



Richard Bigelow and Stephen Caine, developers of the new computer language being used at Caltech.

Caltech researchers conduct earthquake simulating tests from the ninth floor of Millikan Library.

EARTHQUAKE ENGINEERING RESEARCH

Vibrations generated by two shaking machines being used to study the dynamic properties of Caltech's new Millikan Library not only shook the library in recent tests, but shook the ground throughout the entire Pasadena area and were detected by a seismograph more than eight miles away at Mount Wilson. The tremors produced by the two, ½-horsepower vibration generators installed on the ninth floor of the unfinished building were part of a series of earthquake simulating tests conducted by Caltech graduate student Julio Kuroiwa. The test shaking, done under the supervision of Paul C. Jennings, assistant professor of applied mechanics, is also part of the Institute's research program in earthquake engineering.

When the instruments at Caltech's Seismological Laboratory more than three miles away first began to record the unusual ground motion, the engineers there did not know their source. Clarence Allen, interim director of the laboratory, who knew that the building tests were being conducted, suggested they were probably responsible. To verify this, Dr. Jennings and Kuroiwa turned the shaking machines on and off, producing a "coded earthquake." The signals were clearly recorded by the seismological laboratory instruments.

Waves generated by natural earthquakes are often used to study the nature of the earth's interior. The intensities and velocities of the waves are altered by different geologic formations. By studying these changes in the waves, geologists can learn something about the material through which the waves pass. Dr. Allen and Ronald F. Scott, Caltech associate professor of civil engineering, decided to take advantage of the artificially induced earthquake waves to obtain information about the ground in the Pasadena area.

On December 18 Dr. Allen and seismological engineer Francis Lehner set up five portable seismometers at specific locations in Pasadena and Altadena. While Dr. Jennings and Kuroiwa operated the shaking machines, Lehner and Drs. Allen and Scott took readings on the seismometers. The tests were made between the hours of 11 p.m. and 3:30 a.m. when the ground was the least likely to be disturbed by vibrations from traffic and other sources. A sixth portable instrument was moved around to a dozen different locations during the four-hour period, and readings were taken on it at various distances from the library to determine the effects of distance and local geology on the ground motion.

Later it was discovered that the shaking had also been recorded at the permanent Caltech seismograph station on Mount Wilson.

"We didn't expect to detect the waves as far away as that," says Dr. Jennings. "It appears that shaking a multi-story building is a good way to get energy into the ground, and this method may lead to improved techniques for studying the effects of local geology upon earthquake motions."

In the tests of the building, which were done to determine how it would behave during an earthquake, the shaking was north-south, east-west, and torsional. The strongest ground shaking was produced when the building was vibrating north-south, because it is more rigid in that direction.

Ground shaking could be felt in the immediate vicinity of the structure but not by anyone standing more than a few feet away. It is estimated that the top of the building, which oscillated a maximum of about 0.1 inch, shook with about ten percent of the intensity that would be felt during a strong earthquake. No damage was expected during the tests, and none was observed.

NEWS for 1966 1967 ENGINEERING GRADUATES

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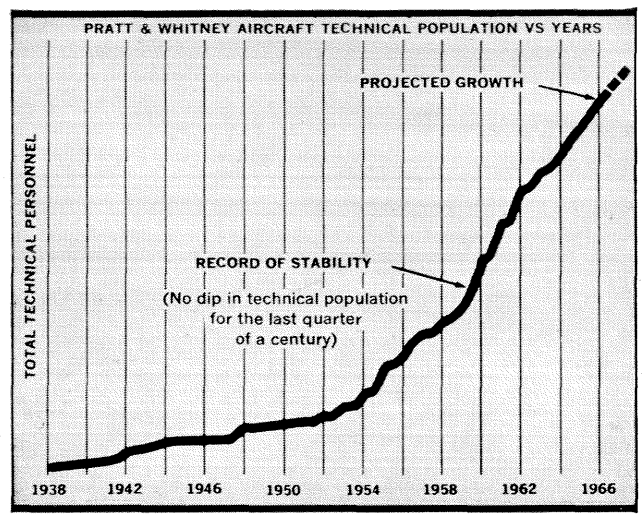

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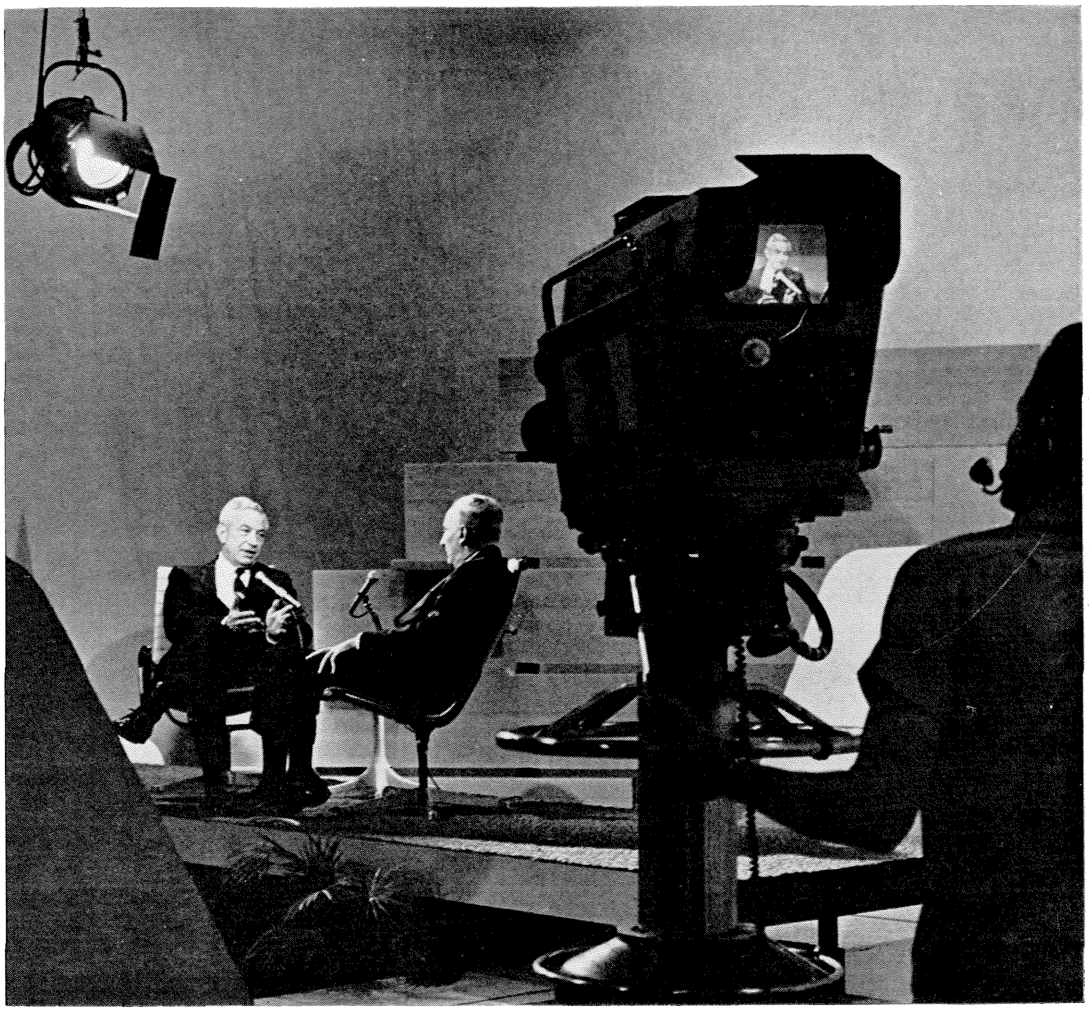


TELEVISION CONVERSATION

Caltech's President Lee A. DuBridge and Simon Ramo, member of the Caltech board of trustees and president of the Bunker-Ramo Corp., will discuss "Science and Society . . . a Race Against Time," on KCET, Channel 28, March 15 at 9 p.m. The program will be repeated March 18 at 10:30 p.m. Their half-hour conversation, one of National Educational Television's series entitled "Spectrum," will be shown on all NET affiliated stations throughout the country during the month.

THE MONTH AT CALTECH

HONORS AND AWARDS

Robert F. Christy, Caltech professor of theoretical physics, has been awarded the Eddington Medal of the Royal Astronomical Society of London for his calculations on variable stars, specifically "his work on the non-linear theory of pulsating stars, which has enabled a close comparison to be made with observations of Cepheids and RR Lyrae variables."

The medal, commemorating the late Sir Arthur Eddington, British astrophysicist, is awarded for investigation in astronomy, with preference for theoretical astronomy.

Robert B. Leighton, Caltech professor of physics and staff member of the Mt. Wilson and Palomar Observatories, has been awarded the space science award of the American Institute of Aeronautics and Astronautics. Dr. Leighton was cited for "outstanding achievements in astronomy and in astrophysics, particularly in solar surface studies and in Mariner IV studies of Mars." Among these achievements are his observations of the huge atmospheric waves rising and falling on the sun, made with a Doppler camera that he invented, and his work as chief investigator of the television picture experiment of Mariner IV.

SCIENCE MUSEUM STUDY

Six Caltech men have been appointed to a seven-member committee set up this month to study the possibilities of establishing a science museum in Pasadena: Horace Babcock ('34), director of the Mt. Wilson and Palomar Observatories; Theodore C. Combs ('27), director of alumni relations; Victor Neher (PhD '31), professor of physics; Robert W. Oliver, associate professor of economics; William Pickering ('32, MS '33, PhD '36), director of Caltech's Jet Propulsion Laboratory; and A. M. Zarem (MS '40, PhD '44), president of Electro-Optical Systems, Inc. The proposal for a science museum, with the emphasis to be on Pasadena's contribution to space exploration, was made by Dr. Neher.

EARTHQUAKE RESEARCH SUPPORT

Caltech has organized a new program, the Earthquake Research Affiliates, to provide broader support for earthquake research and to establish closer liaison between corporations and the Institute. Because of the potential of increased damage from earthquakes, due to denser population and urban complexities, many concerned groups in industry and government have shown interest in earthquake research information.

Seven companies currently supporting the Institute's studies in this field have been designated founders of the new program, and affiliate memberships have been made available. Although the program is basically for research support, members will receive special communications and will have the opportunity to participate in conferences on the Caltech campus and in field trips.

NEW APPOINTMENTS

Caltech's Harrison Brown has accepted a joint appointment as professor of geochemistry with the division of geological sciences and as professor of science and government with the division of the humanities and social sciences. Dr. Brown has been on the Institute faculty since 1951 in the former capacity; he assumes his new responsibilities as a result of the humanities' increasing emphasis on the relationship of science and government.

As foreign secretary of the National Academy of Sciences, Dr. Brown spends a great deal of time in Washington, D. C., examining in depth the interrelationship of scientific activity and government. Within the Academy he has been responsible for setting up major international scientific endeavors, including the programs of the International Council of Scientific Unions and scientific exchanges between eastern European countries and the United States. He has initiated a series of programs for selected developing countries aimed at strengthening their scientific competence in relation to economic and agricultural development.

In his new appointment in the humanities division he will be concerned with the politics of science and with the economic, political, and social development of non-Western countries. As an active member of the division he will participate in interdisciplinary social science courses and seminars, arrange for specialists in science and government to visit the campus, and will help coordinate visits of students to Washington.

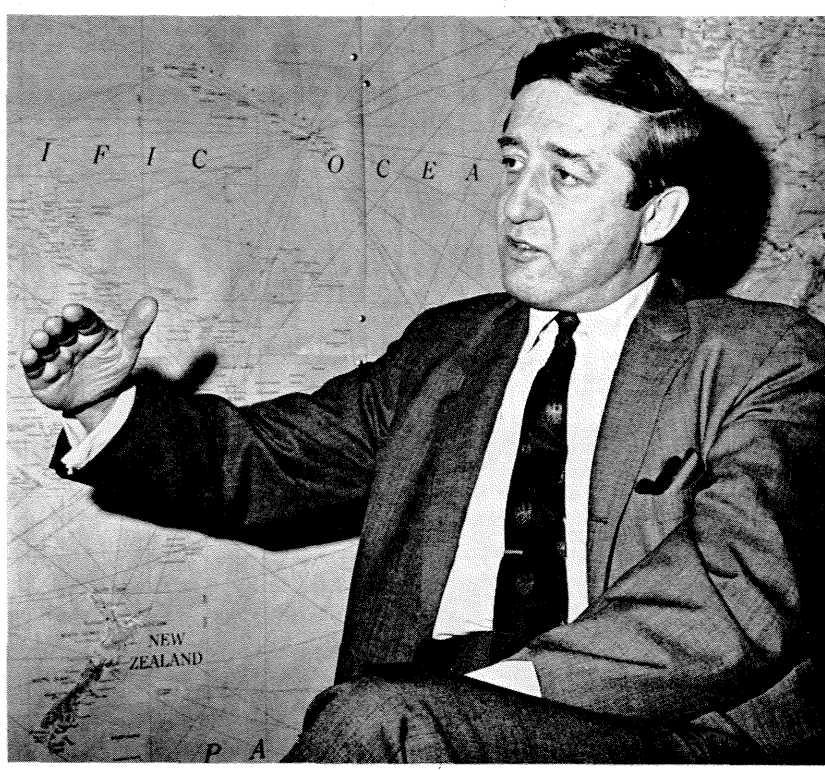
Lyman G. Bonner, Caltech director of foundation relations, has received a new appointment as assistant to the president of the Institute. He will represent the president's office as coordinator of campus development and will maintain liaison with federal agencies that support research.

Replacing Dr. Bonner as director of foundation relations is Edward P. Hanak, who has been serving as associate director of corporate relations. He will be responsible for establishing and maintaining Caltech's relationships with private foundations supporting higher education.

Frederick W. Mintz, currently a senior buyer for Caltech's procurement department, will succeed Mr. Hanak in corporate relations.

BROKEN PRECEDENT

For the first time in the history of Caltech an underclassman has been elected student body president. Joe Rhodes, sophomore physics major from Pittsburgh, won over three upperclassmen opponents by a 70 percent majority. Although in the past ASCIT by-laws have limited the candidacy to upperclassmen, a revision of the by-laws changing this limitation was approved at a special student body election early in February.



Harrison Brown, professor of geochemistry.

Twenty-five hundred dollars in cash awards to engineering and metallurgy students.

The Forging Industry Educational and Research Foundation announces a $2,500 award competition for the best paper on the subject "How Mechanical and Physical Properties of Impression Die Forgings Are Best Utilized in Designing Forgings for New Applications." First prize, $1,000, plus eight other awards totaling $1,500.

Competition is open to senior and graduate engineering and metallurgy students. Length of the paper, 3,000 to 3,500 words. Deadline for completed paper: May 10, 1967.

Winner and his faculty advisor will also receive an all-expense-paid trip to White Sulphur Springs, West Virginia, where the award presentation will be made at the 1967 meeting of the Foundation.

For full details fill in and mail the coupon or write:

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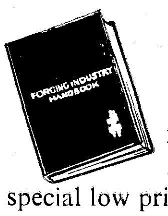
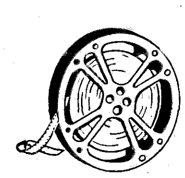
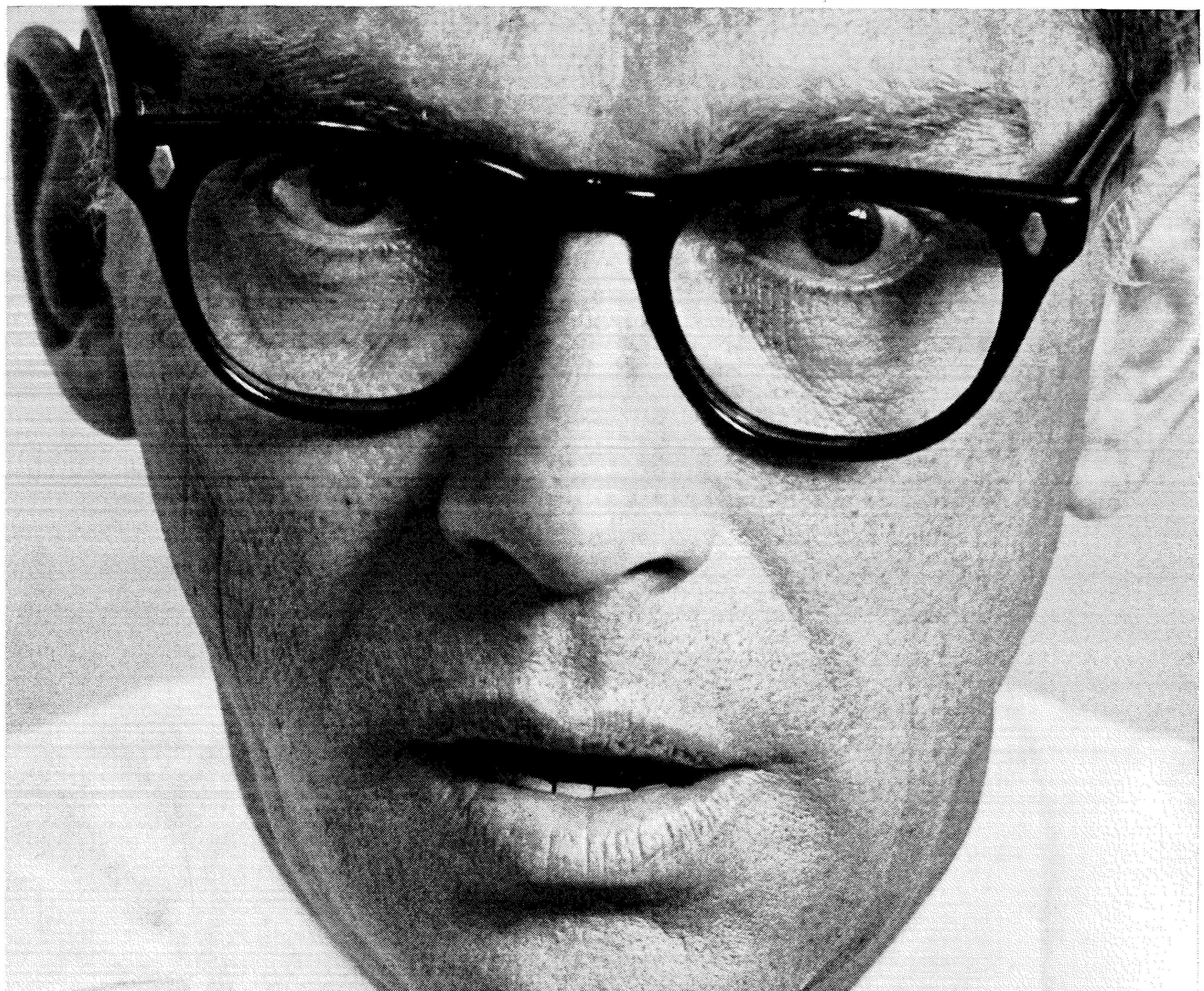


New hardbound 520-page *FORGING INDUSTRY HANDBOOK*, describing forging design, applications and technology, is available to students at special low price of $2.50. Write, enclosing check or money order, to Forging Industry Association, 55 Public Square, Cleveland, Ohio 44113.



16-millimeter sound and color film, *TO BE FORGED*, describes forging process and design considerations. Length 18 minutes. Sponsored by Forging Industry Association, available on loan free from regional film libraries of Modern Talking Picture Service, Inc., 1212 Avenue of the Americas, New York, N.Y. 10036.



TRAVELING TUTORS

The Caltech YMCA is now running three off-campus tutoring programs, involving about 90 Caltech students. The oldest of these, the program at Jordan High School in the Watts section of Los Angeles, began four years ago and now utilizes the services of nearly 40 undergraduate and graduate students. A second tutoring project, at the Westside Study Center, helps Pasadena school children from the first through the tenth grades. The third program began in January at Pasadena's Washington Junior High School.

Every Tuesday and Thursday evening, two or three carloads of assorted physics, math, engineering, biology, and humanities majors brave the freeways and take the 45-minute ride to Jordan High. There the tutors congregate in a classroom converted into a dispatch center, where they are put in touch with the students who are in need of help in a particular subject. Math and science tutors are most in demand. The Caltech students usually do not stick to one subject week after week, but range from algebra to geometry to chemistry. One undergrad holds a music class. The Jordan students are not forced to attend these evening sessions, but they are quite interested in improving themselves and come of their own volition. The turnout averages about two or three students to a tutor. The sessions last about an hour.

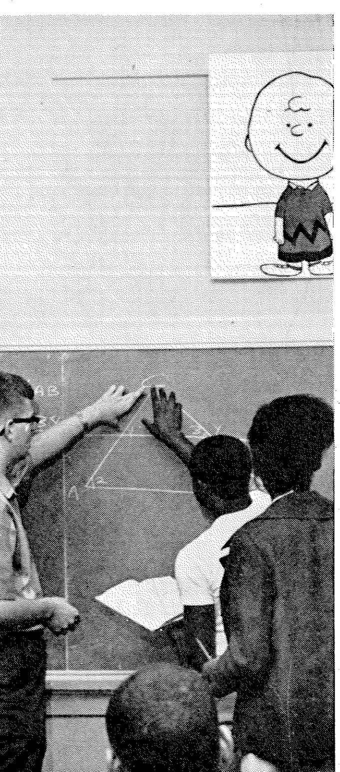
Much of the tutoring time is spent going over homework problems or showing the students how to do problems they missed on a test. At Jordan there are two distinct groups of students—those who need help to keep up with their work, and those who are eager to learn what they normally would not get as a part of their regular curriculum. Working with this group is exciting, since these are the potential leaders of the community, and the help and encouragement they get from the program may not only sustain their interest in high school but may also motivate them to go on to college and advanced fields of study.

In order to work with these bright and highly motivated students, five Caltech undergraduates have organized a course in computer programming. This eight-week course, handled on an informal basis, attempts to explain some of the principles of programming and its applications to a group of about ten Jordan High students, selected on the recommendation of their math teachers. More important, there is a "laboratory session" at Caltech's Booth Computing Center every Saturday afternoon. Here the students get an opportunity to run programs on the new IBM 360/50 computer system. The specific system used is a shared-time remote-console setup using Caltech's own shared-time CITRAN processing system. With the fairly firm grasp of the CITRAN language they now have, the Jordan students are working on individual projects, such as a program to study the growth rate of bacteria as a function of food and other variables, and one to enable the computer to play a game, such as three-dimensional tick-tack-toe or blackjack, against a human opponent.

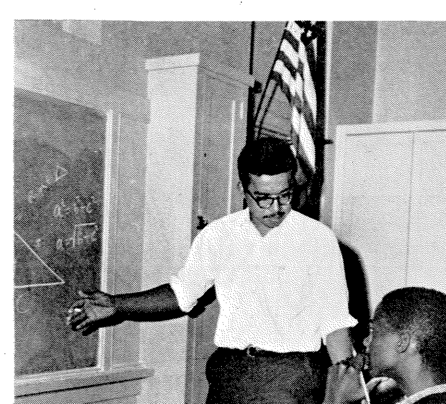
The new Washington Junior High program is radical in its approach to tutoring. The students are tutored *during* class hours, so that the teachers are available for consultation. The entire resources of the school are at the disposal of the tutor, including the audio-visual aids equipment. Some of the Caltech students will be involved in creating instructional tapes that can be used by individual students on the school library's tape recorders. Each tutor works with *one* student.

Occasionally, after hours, a group of the tutors get together with Burton Housman, associate secretary of the Caltech Y, to discuss the philosophy of tutoring and its role in the community. Students agree that tutoring is a crutch, although unfortunately a necessary one. Tutors, like doctors, would like to do themselves out of a job, but at present they can only treat the symptoms.

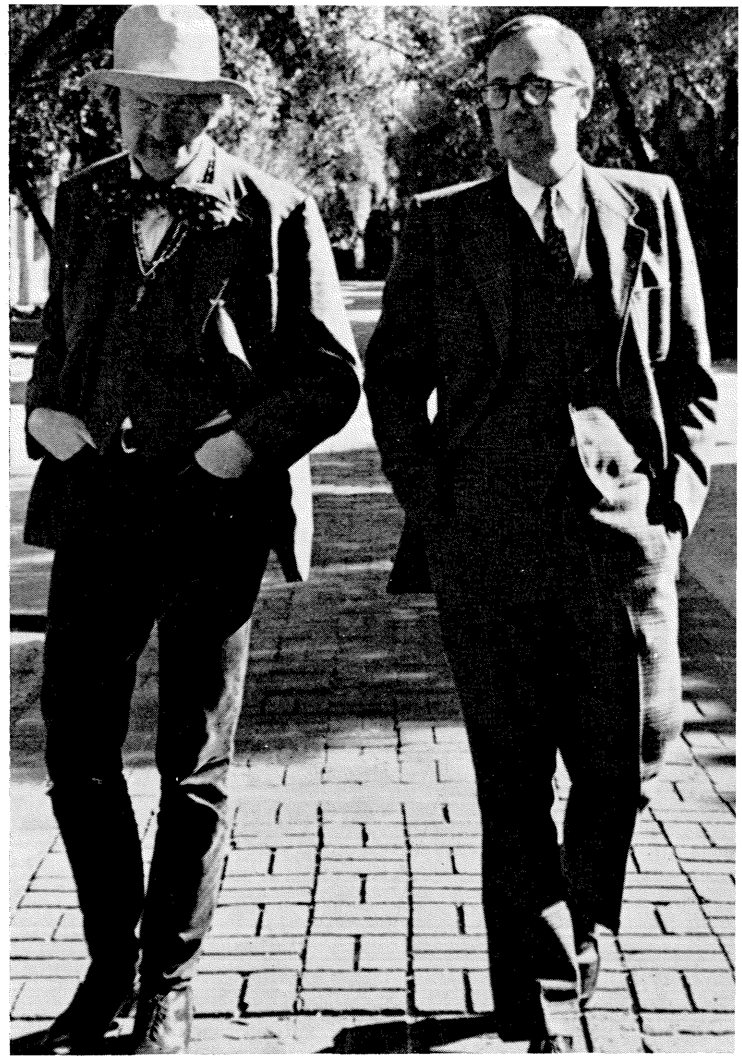
—David Lewin '70




MODERN ALGEBRA



POETS IN TRANSIT



Nattily dressed San Francisco poet Andrew Hoyem finished his half of the January 18th Caltech student assembly with a reading of his macabre and powerful poem, "The Litter," a recounting of his dream visit to the House of Death. For his performance he shed his customary outgoingness. There was quiet and respect in the student audience.

The second reader was ruddy-faced Richard Brautigan, wearing a floppy Stetson hat, an old vest, adorned from head to toe with two necklaces, a San Francisco dog tag, and Italian studded shoes. By the time he had read "My nose is growing old this year," a lament on his future prospects as a lover, he had found a habitation among Caltech students.

Andrew and Richard stayed on campus for ten days living in the guest suite at Ricketts house. At first it was sort of a mutual zoo, the poets peeking at the students from behind moats and bars—with neither group being sure which were the bipeds and which the quadrupeds. After the first shock, the students and poets tried to get used to each other.

When Richard walked by a stunned campus-tour-guide, the student was heard to exclaim, "Oh, he can't be a Tecker! We're more normal than *that!*"

A few students followed these pied pipers from the beginning; more were attracted as they stayed on. The poets visited the humanities division secretaries with schemes for the salvation of the Institute or themselves. They sought for girls and for classes with whom to share experiences and—ultimately—tried to find the tools of science and the scientists. At times they were awed and discomfitted by teaching, science, and the power of technology.

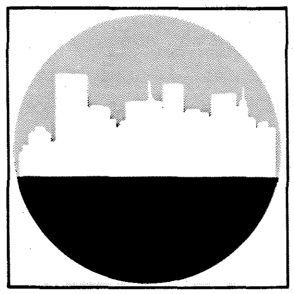
But, by the end, a kind of symmetry was gained. At the last coffee hour some 50 students assembled to hear the poets read. Richard and Andrew were happy; they had just met Richard Feynman and discussed his passion for beautiful formulae with him. And Andrew had met a lovely blonde girl. Richard, from behind his flaxen moustache, remarked sagely, "Don't wash that hand, Andrew; it has been shaken by a Nobel Prizewinner and a Girl."

John F. Crawford, Instructor in English

BRIC-A-BRAC

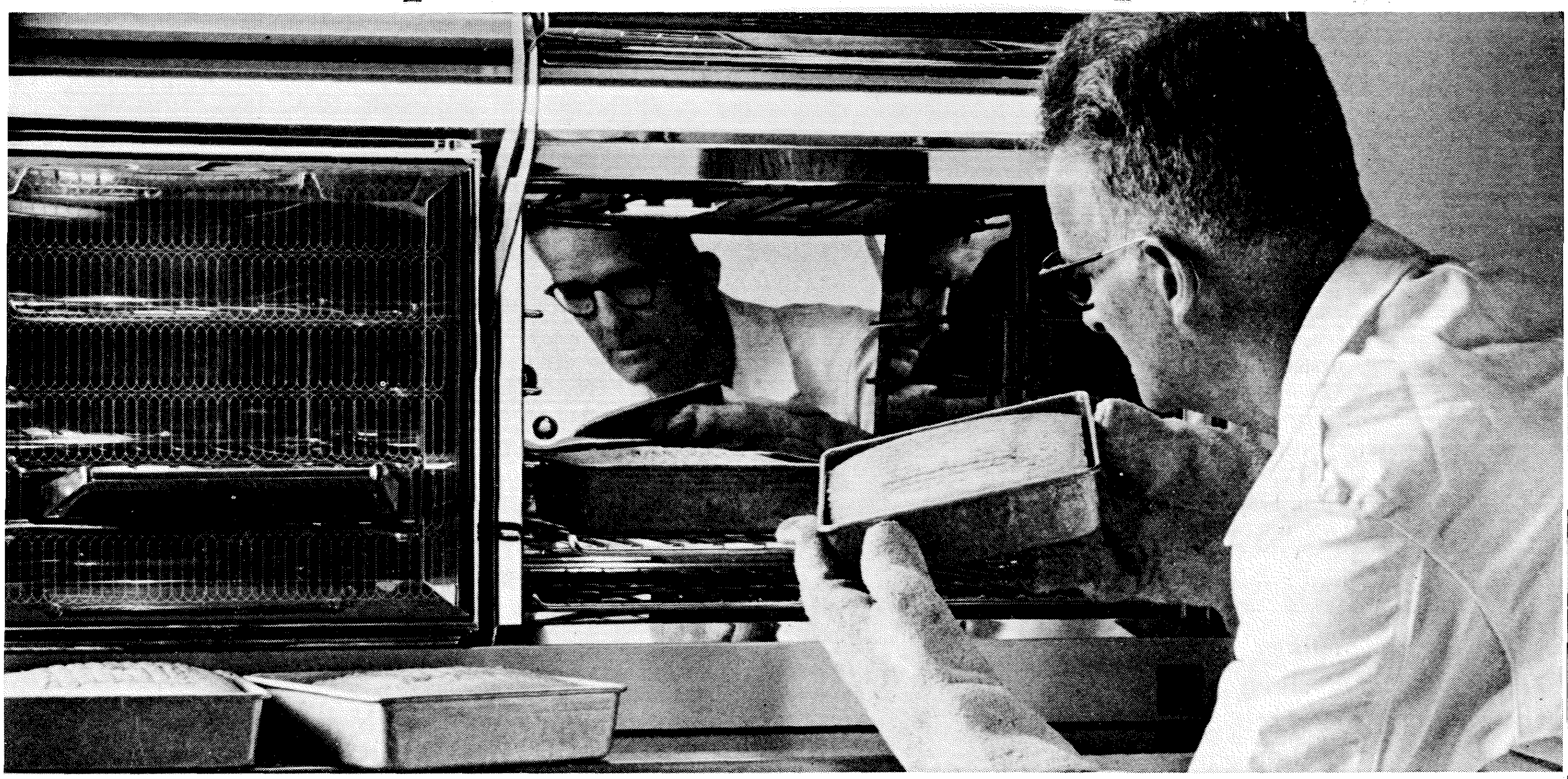
A prose poem written by Andrew Hoyem during his stay at Ricketts House.

This courtyard is paved with brick. Its bricks create a deceptive impression, that of a woven mat. Two bricks this way, two bricks that way weave over the ground. Imitation early California architecture rises on the periphery of this courtyard. Tropical plants grow parallel to minor columns in support of shade over walkways. One and only one shadow divides the courtyard into night and day. In its center sits an enormous empty urn of pink marble. At the bottom of this voluminous vase a small puddle of brackish water slowly evaporates. Over centuries, monks in legion tread these stones on the path to righteousness. Revolutionaries have been shot against these selfsame walls. Fatal balls are embedded within their two foot thicknesses. Spanish ladies have clattered over these cobbles, dancing in inmates' dreams. Odors of institutional food permeate these corridors. Where once the mere suggestion of perfume enticed others around the bends of endless catacombs, now the scents of stifled desire and a faulty sewage system lurk like the devils of distraction. Purpose is written all over the place. Viva Villa was scrawled on an arch half a century past. Prisoners of their own volition reside behind barred windows. Students of science occupy these hallowed halls. They are in full possession of all their faculties. Hired hands are at their beck and call. A bullish buyer's market exists on the educational averages. Young men will vault the barricades swinging brickbats before this is over. You are the hope of the future. Times are changing. We have gained the hour. Stop the war. Please pass the ammunition. I want a second helping. Give us more astronomers. Give us more starlets. Thank you, Caltech. Thank you, Hollywood.



Youthful chef for the outdoor set

now cooks up some answers for GM's Frigidaire



Dawn was breaking over Buckeye Lake in the summer of 1920. Over a campfire the tantalizing aroma of breakfast was in the air. And breakfast was the responsibility of young Lawrence Howdyshell, top cook in the troop.

It was at Buckeye Lake that "Howdy" developed his talent for cooking that paid off in later years when he became a range and oven-tester at the Frigidaire Division of General Motors in Dayton, Ohio.

Now, "Howdy" bakes cakes and broils steaks—he cooks both fast and slow, with heats high and low, to test the performance of Frigidaire ovens and ranges. "Howdy" is one of the housewife's representatives at the factory, searching for anything that *might cause complaints in the kitchen.*

He started with Frigidaire in 1931 as an inspector of refrigerators, but for the past 13 years has devoted full time to testing ranges.

"Howdy" and men like him play an important part in the development of Frigidaire ranges. We're glad he's cooking for Frigidaire. His experiments in the test kitchens can make *any housewife a better cook.*

General Motors is people making better things for you.

GM

MARK OF EXCELLENCE

1923

CLARENCE R. OWENS and his wife were killed in a traffic accident in January. The news was reported to Caltech by their son, Frederick. Owens was retired and lived in Chino, Calif.

1925

LINUS PAULING, PhD, Caltech research associate in chemistry and a staff member of the Center for the Study of Democratic Institutions in Santa Barbara, recently became the first recipient of the Linus Pauling Medal. This award, established by the Puget Sound and Oregon sections of the American Chemical Society, will be given annually for outstanding achievement in chemistry.

1927

O. F. RITZMANN retired in December after 37 years with the Gulf Oil Corporation in Pittsburgh. In November he was awarded an honorary membership in the Society of Exploration Geophysicists in recognition of his distinguished contributions to geophysics and to the society.

1928

W. MORTON JACOBS has assumed the presidency of the Southern California Gas Company. He moves to this position from the Pacific Lighting Service and Supply Co., where he has been serving as president since 1961.

1929

LESLIE OWEN SCOTT died in November in Visalia, Calif., of a heart attack. Scott had been operating his own distributing company for engineering equipment—Valesco, Inc.—since 1955 when he retired as a colonel in the U. S. Army Corps of Engineers.

1930

WARREN N. ARNQUIST, PhD, is a research scientist in the advanced research laboratories of Douglas Aircraft Co., Inc., in Huntington Beach, Calif. He reports that he was leader of the company's solar eclipse expedition to Arequipa, Peru, last November.

GEORGE L. REYNOLDS is business manager of the Southern California Presbyterian Homes, which operates three retirement homes in the area.

ROBERT W. WILSON, MS '32, PhD '36, professor of paleontology and director of the Museum of Geology at the South Dakota School of Mines and Technology, has been awarded a Fulbright research award by the Austrian-American Educational Commission for a year at the University of Vienna. He will be doing paleontological research of fossil vertebrate faunas of the Vienna Basin in an attempt to correlate them in time with the fossil faunas of the high plains area of the U.S. Wilson, who has been with the South Dakota school since 1961, will begin his sabbatical in September, 1967.

1931

RUSSELL L. BIDDLE, PhD, who retired recently from the City College of New York, is professor in the department of biological sciences at Florida Atlantic University in Boca Raton.

PERRY M. BOOTHE, MS '32, a captain in the U.S. Navy, is now serving on General William Westmoreland's staff in Saigon, Vietnam.

1933

E. R. KENNEDY, MS '34, PhD '36, an engineer of materials research for the Port of New York Authority, is heading a group recruited to undertake basic research to discover areas where chemistry and physics can aid civil engineers.

J. CLIFTON SPADE will return home from Germany in June after working for a year and a half on the F-104G airplane test program for Lockheed Aircraft Corp.

1934

ROBERT O. BOYKIN JR. is with Esso Chemical Inter-America in Coral Gables, Fla. He is working in construction management as a part of Esso's program for building fertilizer and chemical plants throughout Latin America.

1935

KENNETH S. PITZER, president of Rice University in Houston, Tex., has been elected a trustee of the Carnegie Foundation for the Advancement of Teaching.

VERNE LEON PEUGH died suddenly in October at his home in Belmont, Calif. He was 67. Peugh had been active in the engineering field for many years and had been lecturing at Stanford University since 1963. He is survived by his wife, a daughter, and four grandchildren.

1936

EUCLID V. WATTS, a vice president with the Mobil Oil Company, died in Houston in December. Watts joined Mobil in 1936 and became a vice president in 1959. Survivors include his wife, a son, and two daughters.

1937

ERNEST MONCRIEF has been appointed vice president of the Houston division of the Fluor Corporation, Ltd. Moncrief, who joined Fluor in 1937 as a project engineer, has served as vice president of project and design engineering at the company's headquarters in Los Angeles since 1962.

1938

SIDNEY BERTRAM, a staff scientist with the Bunker-Ramo Corporation in Canoga Park, Calif., was elected a fellow by the IEEE for "contributions to sonar and to the design of computer driven stereomapping systems."

MUNSON W. DOWD, MS '46, has been named to the new position of chief design engineer for the Metropolitan Water District of Southern California.

J. KNEELAND NUNAN, MS, has accepted an invitation to become assistant director of defense research and engineering in the office of the Secretary of Defense in Washington, D.C.

1940

ROBERT B. YOUNG, vice president of Aerojet-General Corp., has been elected a fellow in the American Institute of Astronautics and Aeronautics.

1941

GILBERT A. JONES announces his entry into private practice as a consulting engineer in Glendale, Calif. He will specialize in the planning, design, and construction of water pumping and distribution systems. Jones was previously chief electrical and mechanical engineer for Bookman-Edmonston Engineering, Inc., of Glendale.

1942

STEWART DAVIS has recently been elected vice president of the Syracuse Supply Co. in New York. He has been manager of the company.

1944

ROBERT J. PARKS, Surveyor Project manager at Caltech's JPL, recently received the Air Force Association citation as Aerospace Industry "Man of the Year."

1945

DUANE T. McRUER, MS '48, president of Systems Technology, Inc., in Hawthorne, Calif., has been elected a fellow of the Institute of Electrical and Electronic Engineers.

1946

WARREN W. BERNING, MS, chief of the ballistic measurements laboratory in the Ballistic Research Laboratories in Baltimore, was head of the joint U.S.-Brazilian effort to make atmospheric studies near

Rio de Janeiro during the total solar eclipse last November. As technical director of the U.S. Defense Atomic Support Agency's solar eclipse expedition to South America, Berning organized and directed the launch of the Nike missile which gathered information about the eclipse.

JOHN S. SHOWELL, MS '49, has joined the National Science Foundation in Washington, D.C., as associate program director for organic chemistry. He has been senior research chemist at the Eastern Regional Research Laboratory in Philadelphia.

1947

CHARLES M. DUKE, MS '47, a brigadier general in the U.S. Army Corps of Engineers, has been assigned to Vietnam as deputy engineer and deputy commander of engineer troops. Duke and his wife, Vernice, have a son at the University of North Carolina and a daughter in junior high school in Washington, D.C.

DAVID P. SHOEMAKER, PhD, left this month for a half-year sabbatical at the Laboratoire d'Electrostatique et de Physique du Metal at Grenoble, France.

E. ARTHUR TRABANT, PhD, has been appointed vice president for academic affairs for the Georgia Institute of Technology in Atlanta. Prior to this appointment Trabant was dean of the school of engineering at the State University of New York in Buffalo.

1949

WILLIAM E. ARCHER and his family will leave their Portuguese Bend, Calif., home in February to sail around the world, via the South Seas, aboard their 60-foot staysail schooner Mytoy. The Archers and another family, co-owners of the Mytoy, will stop at La Paz and Honolulu. Archer plans to resign from his position as a mechanical engineer in research and development at Western Precipitation Inc., in Los Angeles.

BYRON C. KARZAS has been elected a vice president of Duff and Phelps, Inc., of Chicago, a public utility investment and financial analysts firm. Karzas joined the company in 1956 and has served as an assistant vice president since 1965.

1950

WILLIAM D. WARTERS, MS, PhD '53, has been promoted to director of the transmission systems research center of the Bell Telephone Laboratories in New Jersey. Since joining Bell Laboratories in 1953, Warters has been engaged in waveguide research. He has been head of the company's repeater research department since 1961.

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1951

H. KENDALL REYNOLDS, MS, PhD '53, has returned from 18 months in Ecuador as advisor for basic sciences in the University of Houston's program of assistance to the University of Guayaquil.

ROBERT E. TRUDEL JR., MS, veteran aerospace manager, has been promoted to head a new section in the Lockheed Missiles and Space Co. He will manage the newly created advanced strategic programs in Lockheed's research, development, and missiles division at Sunnyvale.

WILLIAM W. WATKIN JR., MS, a colonel in the U.S. Army Corps of Engineers, is the new district chief for the Philadelphia district, which includes the entire Delaware River Basin.

1952

HENRY L. RICHTER JR., PhD '56, has been appointed development manager for UCLA's new Mountain Park research campus in the Santa Monica Mountains of California. Richter was formerly vice president and technical director of Electro-Optical Systems, Inc., in Pasadena, where he played a key role in the company's work on the Ranger, Mariner, and Gemini space programs.

WILLIAM L. WISE has joined Melabs in Palo Alto, Calif., as manager of the ECM systems engineering department. Prior to this he was with Philco on the multi-eject military satellite program. The Wises have three daughters, ages 12, 11, 6, and two sons 14 and 9.

1953

H. ROBERT HUNT, MS, is working for the Marathon International Oil Company as a geophysical interpreter-supervisor on foreign assignments. Although based in Findlay, Ohio, Hunt frequently travels to Bogota, Colombia, to oversee the company's jungle operations.

1954

WILLIAM D. HARKINS, AE, a commander in the U.S. Navy, has been appointed production manager for the overhaul and repair department at the Naval Air Station in Jacksonville, Fla.

L. WILLARD RICHARDS was married to Nancy Cutter on October 1.

DON E. ROGERS, AE, senior technical staff member at Aerospace Corp. in San Bernardino, has been promoted to director of the arms control office in the company's weapon systems division. Rogers joined Aerospace in El Segundo in 1962 and transferred to San Bernardino in 1963. Before joining the company, he was associate professor of mechanical engineering and associate professor of aeronautical and astronautical engineering at the University of Michigan in Ann Arbor.

ROBERT L. SMITH, MS '55, has been promoted to director of the Minuteman program office in the weapon systems division of the Aerospace Corp., in San Bernardino. Formerly associated with the Minuteman office at TRW, Inc., Smith joined Aerospace in 1962 as a member of the technical staff.

1955

GEORGE T. JAMES JR., MS, AE, was recently promoted to lieutenant colonel in the U.S. Air Force and is currently in charge of system control at the Satellite Test Center at Sunnyvale, Calif.

1956

STUART W. BOWEN is assistant professor of aerospace engineering at the University of Michigan in Ann Arbor. He recently received his PhD in aerospace science from the university.

DONALD C. BROOKS is a newly appointed administrative engineer for the Municipal Water District of Southern California. He is based in Los Angeles.

BYRON B. JOHNSON JR. has been appointed director of public works for Palos Verdes Estates, Calif.

1957

JEROLD L. SWEDLOW, PhD '65, is assistant professor in the department of mechanical engineering at the Carnegie Institute of Technology, teaching and doing research in solid mechanics under the sponsorship of NASA.

GORDON R. WICKER, MS, has been appointed assistant manager of the Shell Chemical Company's laboratory-technology department in Denver. He was formerly a research engineer in the company's Emeryville, Calif., research center. This is his tenth year with Shell.

C. ALLEN WORTLEY, MS, has joined Warzyn Engineering and Service Company, Inc., in Madison, Wis., as chief engineer. The firm practices civil engineering with emphasis on structural and soils work. Wortley was formerly a partner in his own firm in Pittsburgh.

1958

JOSEPH M. KIERNAN JR., MS, a lieutenant colonel in the U.S. Army, has been in Vietnam since July, commanding the 1st engineer battalion of the 1st Infantry division.

HUGO B. FISCHER, MS '63, PhD '66, assistant professor of civil engineering at the University of California in Berkeley, is the first recipient of the University of Minnesota's Lorenz G. Straub Award, presented for a thesis of special merit in hydraulic engineering. Fischer's work is "Longitudinal Dispersion in Laboratory and Natural Streams."

BRUCE McKEEVER, MS '59, has left the General Electric Computer Laboratory in Sunnyvale, Calif., to join Time/Data Corporation as manager—application engineering.

CHARLES R. PENQUITE, MS '59, was recently promoted to senior research chemical engineer in the inorganic division of the Monsanto Co., in St. Louis, Mo. He and his wife, Mary, have a daughter, Cheryl Ann, born last November.

ANDREW PERGA, MS '59, has been named section manager of the precise power department at Electronic Specialty Company's Connecticut division. Before this appointment Perga was technical director in charge of the division's precise power engineering organization.

JAMES I. VETTE, PhD, has been appointed director of the National Space Science Data Center located at the Goddard Space Flight Center, Greenbelt, Md. Vette leaves his position as staff scientist at the space physics laboratory of the Aerospace Corp., in Los Angeles.

T. REID WARRINER and his wife, Sargit, are presently living in Goteborg, Sweden, where Reid is a research fellow in sanitary engineering at the Chalmers Institute of Technology.

1959

DOUGLAS R. CHRISTMAN is with the General Motors Manufacturing Staff in Warren, Mich., where he is involved in materials research and impact forming of metals. He was formerly with the General Motors Defense Research Labs in Santa Barbara, Calif.

JAMES H. HAVEY JR., a captain in the U.S. Air Force, has been graduated from the USAF Aerospace Research Pilot School at Edwards AFB, Calif. Havey was one of 13 students selected from military and civilian pilots for the 12-month course in experimental test and space research pilot training. He is currently assigned to the Air Force Systems Command's aeronautical systems division at Wright-Patterson AFB in Ohio.

1960

GERALD R. JANTSCHER has joined the office of tax analysis in the U.S. Treasury

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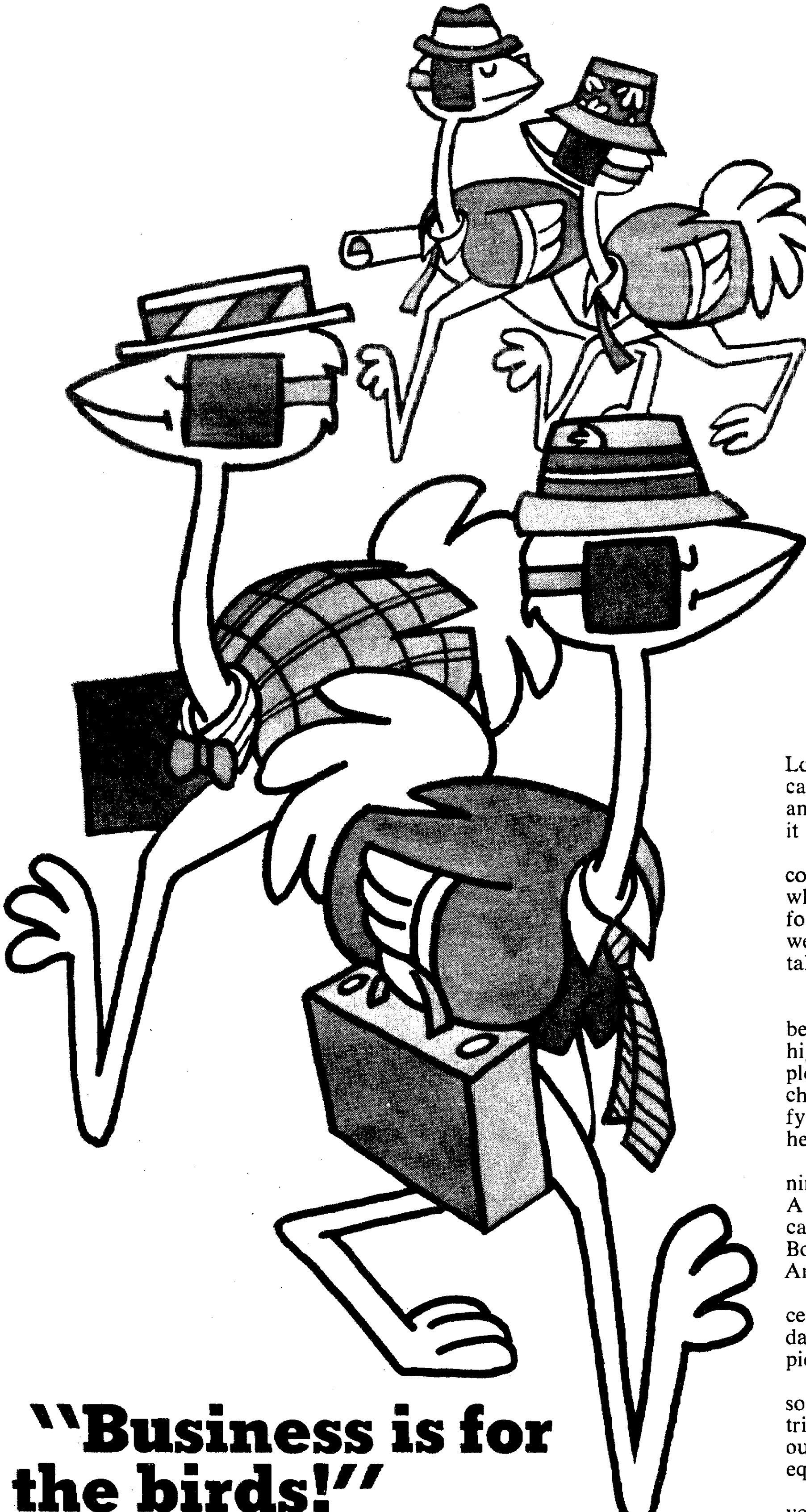


"Business is for the birds!" Who says so?

Lots of people do. Some right on your campus. And for rationale, they point an accusing finger at business and say it lacks "social commitment."

Social commitment? We wish they could visit our Kearny, N. J. plant, where we make cable and apparatus for your Bell telephone company. But we have time for other thoughts, other talents.

Like the situation in nearby Newark.

With civic and business leaders, we began buzzing with ideas. "Let's teach higher skills to some of the un-employed and under-employed. Say, machine shop practice. They could qualify for jobs that are going begging--and help themselves as well."

We lent our tool-and-die shop, evenings. We found volunteer instructors. A community group screened applicants. Another supplied hand tools. The Boys Club donated classroom facilities. Another company sent more instructors.

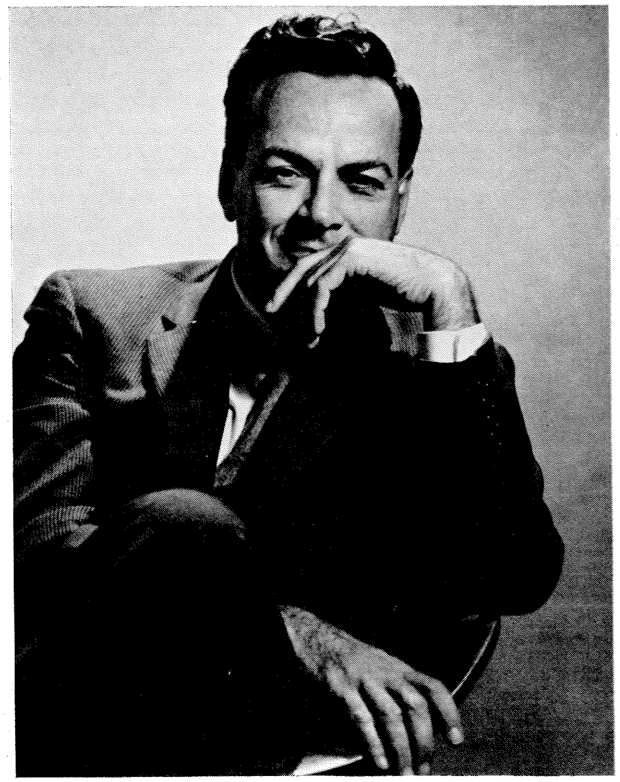
Some 70 trainees enrolled. Their incentive? Self-improvement. Results to date? New people at better jobs. Happier.

And this is only one of dozens of social-minded projects at Western Electric plants across the country, where our first job is making communications equipment for the Bell System.

So, you don't give up ideals when you graduate. If anything, at a company like, say, Western Electric, you add to them. And it's not just a theory. It's practice. Satisfying. Come on and find out. And watch a feathered cliche fly out the window.

BELL SYSTEM **Western Electric**
MANUFACTURING & SUPPLY UNIT OF THE BELL SYSTEM

CALTECH IS WONDER



"The imagination of nature is far, far greater
than the imagination of man.
For instance, how much more remarkable it is
for us all to be stuck
—half of us upside down—
by a mysterious attraction to a spinning ball
that has been swinging in space for billions of years,
than to be carried on the back of an elephant
supported on a tortoise
swimming in a bottomless sea."

—RICHARD P. FEYNMAN
Richard Chace Tolman Professor
of Theoretical Physics

Support your 1966-67 Caltech Alumni Fund

Personals . . . *continued*

Department as a financial economist, after spending a year as a NSF postdoctoral fellow at the University of Manchester in England.

JAMES C. SORENSEN is senior project engineer at Air Products and Chemicals, Inc., in Allentown, Pa.

1964

LESLIE B. ANDERSON III, MS, a first lieutenant in the U. S. Air Force, has entered squadron officer school at the USAF Air University at Maxwell AFB, Ala., where he will study military leadership, management, and use of aerospace forces.

CHARLES F. LEONARD has received a fellowship for research in neurophysiology from the Life Insurance Medical Research Fund. He is at the College of Physicians and Surgeons of Columbia University.

1965

EDWARD S. BAUER was married last December to Margaret Ann Cartwright in Durham, N.C. They are living in Arlington, Va. Bauer is a patent examiner in the U. S. Patent Office in Washington, D. C.

JAY L. FINKELSTEIN, MS, was recently appointed senior analyst at the Air Force Systems Command's new Navy space systems activity in Los Angeles.

ROBERT J. MACEK, PhD, a former captain in the U.S. Army, has been released from active duty and is with the physics department at the University of Pennsylvania in Philadelphia.

1966

WILLIAM L. GAVAN, MS, is with the Standard Oil Company of California in La Habra as an engineer in the offshore producing department.

LETTERS

Pasadena, California

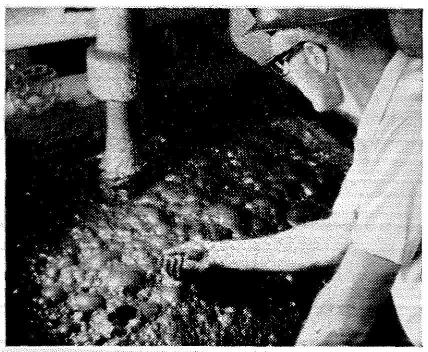
EDITOR:

For my cultured neighbors, it's an odd mistake:
It has to do with *Finnegans Wake*
In *E&S* on page twenty-four.
That apostrophe I do deplore,
In the 48th line of Gell-Mann's particles,
Dropped among adjectives, nouns and articles.
In proofing I know you had to hurry,
So I'll join in and we'll all blame Murray.

JANET LANSBURGH

Opportunities at Anaconda

in mining and metallurgy here and abroad, at Anaconda American Brass Co., Anaconda Wire & Cable Co., and Anaconda Aluminum Co.



Extractive metallurgy is a key to more metal

The metallurgical bubble bath above is a flotation cell in a new Anaconda concentrator. Although it may seem crude and simple to a layman, the process involves complex combinations of colloidal and surface chemistry, crystallography, physics, and special grinding methods adapted to the ores at each individual mine. It represents one way Anaconda's metallurgical research is helping make more metal available for our growing economy.

At Butte, Mont., such research, in raising recovery of metal from low-grade ores, is making today's submarginal material part of tomorrow's ore reserves.

As Anaconda's intensified geological research and exploration turns up new prospective mineral deposits, the need for metallurgical research and development grows. Each deposit must be analyzed to determine the feasibility of recovering its metal. And as research develops more efficient extraction processes, lower grade and more complex deposits can become mines.

To accomplish this, Anaconda is establishing a central extractive metallurgical research center at Tucson, Arizona. It is carefully planned and is being superbly equipped. It is near a large university staff, which can be consulted as needs arise, thus offering a stimulating environment for progressive research and development. In turn, this means attractive new openings for a variety of engineering talents—not only in metallurgy, but also in chemistry, physics, and mechanical engineering.

Dynamic test yields new data on copper-metal springs

Copper metals are among the most useful spring materials known to man. The role of modulus of elasticity in this application was studied at the Research and Technical Center of Anaconda American Brass for more precise data and to make possible predicting spring performance at various ambient temperatures.

Modulus of elasticity can be determined by physical testing in tension or compression. But Anaconda found the dynamic method (below) easier to perform and just as accurate.

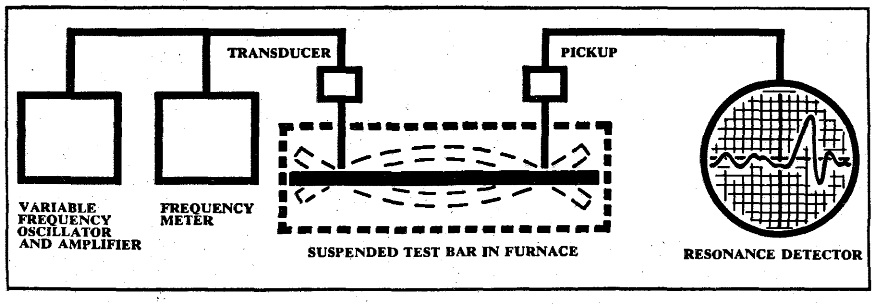
Results are of prime importance to designers of spring devices. The significantly lower modulus of elasticity for copper metals means that at the same level of stress, copper alloy components will deflect or extend almost twice as far as components made of steel—usually with no sacrifice of maximum stress. This can mean more sensitive controls—or "softer" action in the absorption of energy.

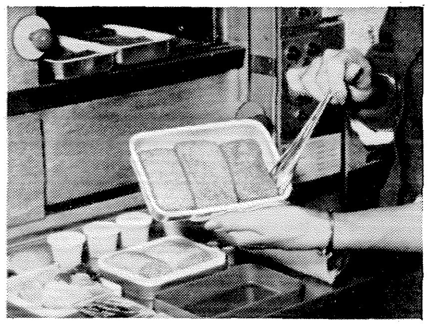
This is but one way Anaconda is refining and broadening knowledge of the many useful properties of copper metals. Such research opens vast new opportunities for growth—career opportunities at Anaconda American Brass for college graduates in all fields of engineering, in business administration, and sales.

The talents and skills of technically qualified men and women will always be needed by Anaconda in important positions in exploration, mining, extractive metallurgy, manufacturing, scientific research, sales, and administration.

If you would like more information about Anaconda or wish to apply for employment, write to: Director of Personnel, The Anaconda Company, 25 Broadway, N.Y., N.Y. 10004.

An Equal Opportunity Employer





Bright future for a bright metal

How do you make containers to hold motor oil or citrus concentrates at lower costs? How can you package airline in-flight meals to enable reconstituting of foods at very high temperatures for fast serving—and retain quality and flavor? These are typical questions asked and answered in the Packaging Development Laboratory of Anaconda Aluminum.

A growing factor in the aluminum industry, Anaconda Aluminum is particularly strong in packaging—with plain foil, laminated foil and rigid foil container products. And it has developed several firsts in the aluminum industry. One is the patented foil-fibre container for motor oil and for citrus concentrates. Another is foil containers (see above) for better airline service in the jet age. Now frozen and refrigerated meals can be heated rapidly and served quickly. Anaconda Aluminum has an outstanding record of developments which have had a tremendous impact on the packaging industry.

Anaconda Aluminum is also a producer of primary aluminum. To meet the growing demand for the metal in packaging, transportation, electrical, and building products, Anaconda Aluminum has been steadily increasing its output—is currently expanding its primary ingot capacity by two-thirds. This expansion involves an investment of $50,000,000.

Anaconda Alumium is growing, and will become an increasingly important factor in the bright future of the bright metal. For this it needs people—not only for its packaging laboratory and foil operations, but also for its other fabricating plants and reduction operations. This means growing opportunities for metallurgists, chemical engineers, industrial engineers, plant engineers, and system engineers. 66125

Left: Dynamic test for modulus of elasticity. Oscillator changes frequency until test bar begins to vibrate. From natural frequency shown on oscilloscope, "dynamic modulus" can be computed.

30th ANNUAL ALUMNI SEMINAR

April 22, 1967

An outstanding program of lectures
to be given by:

T. M. Apostol, Professor of Mathematics

J. F. Bonner, Professor of Biology

S. K. Friedlander, Professor of Chemical Engineering and Environmental Health Engineering

A. J. Haagen-Smit, Professor of Bio-organic chemistry

R. A. Huttenback, Professor of History

G. D. McCann, Jr., Professor of Applied Science; Director, Willis H. Booth Computing Center

J. E. McKee, Professor of Environmental Health Engineering

R. J. Parks, Assistant Laboratory Director for Lunar and Planetary Projects

W. L. W. Sargent, Assistant Professor of Astronomy; Staff Member, Mt. Wilson and Palomar Observatories

L. T. Silver, Professor of Geology

R. L. Sinsheimer, Professor of Biophysics

R. L. Woodbury, Instructor in History

Also interesting displays

special lecture for all attendees by

Peter R. Kyropoulos, Technical Director
General Motors Styling Staff

The day will end with a social hour and dinner at the Huntington-Sheraton Hotel

guest speaker

L. Eugene Root, President
Lockheed Missiles and Space Company

Complete program and registration form will be mailed in March

ALUMNI WINE TASTING LECTURE

March 4, 1967

At the Athenaeum

$2.00 per person

Attendance limited to 200

ONLY alumni and their ladies

Reservations accepted in order of receipt

Announcements were mailed February 8

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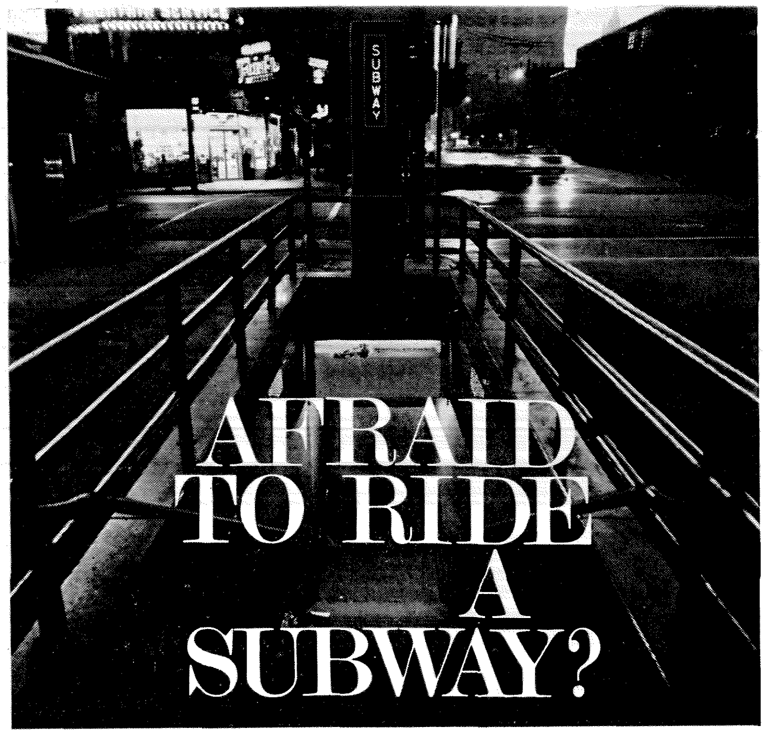

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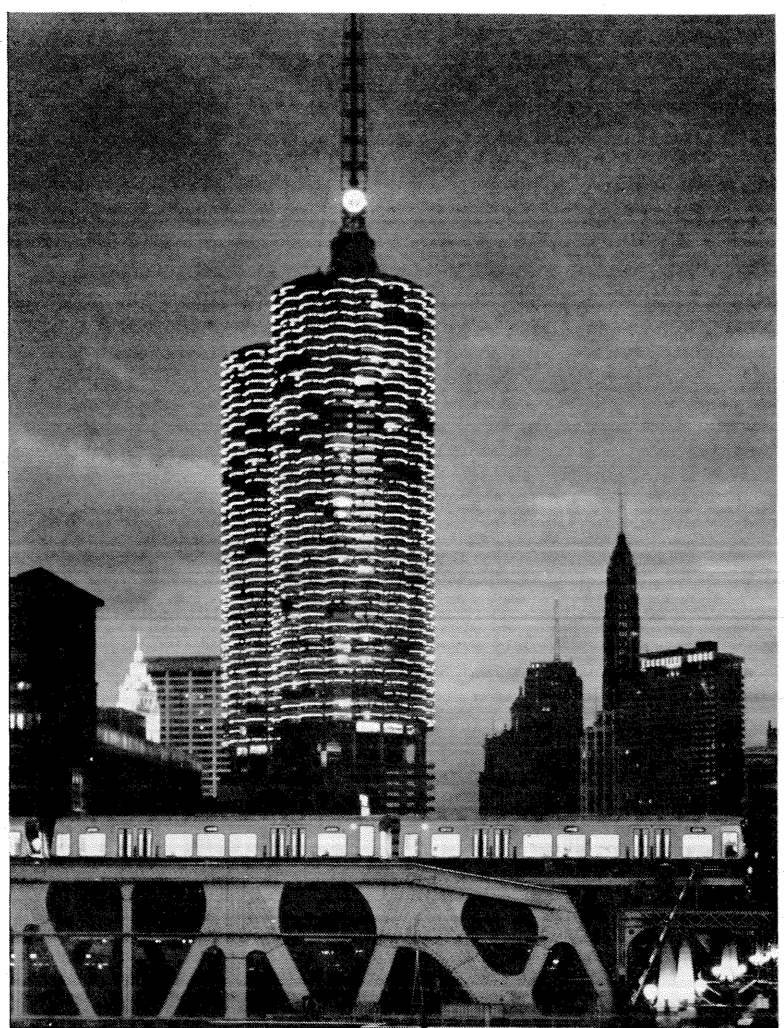

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