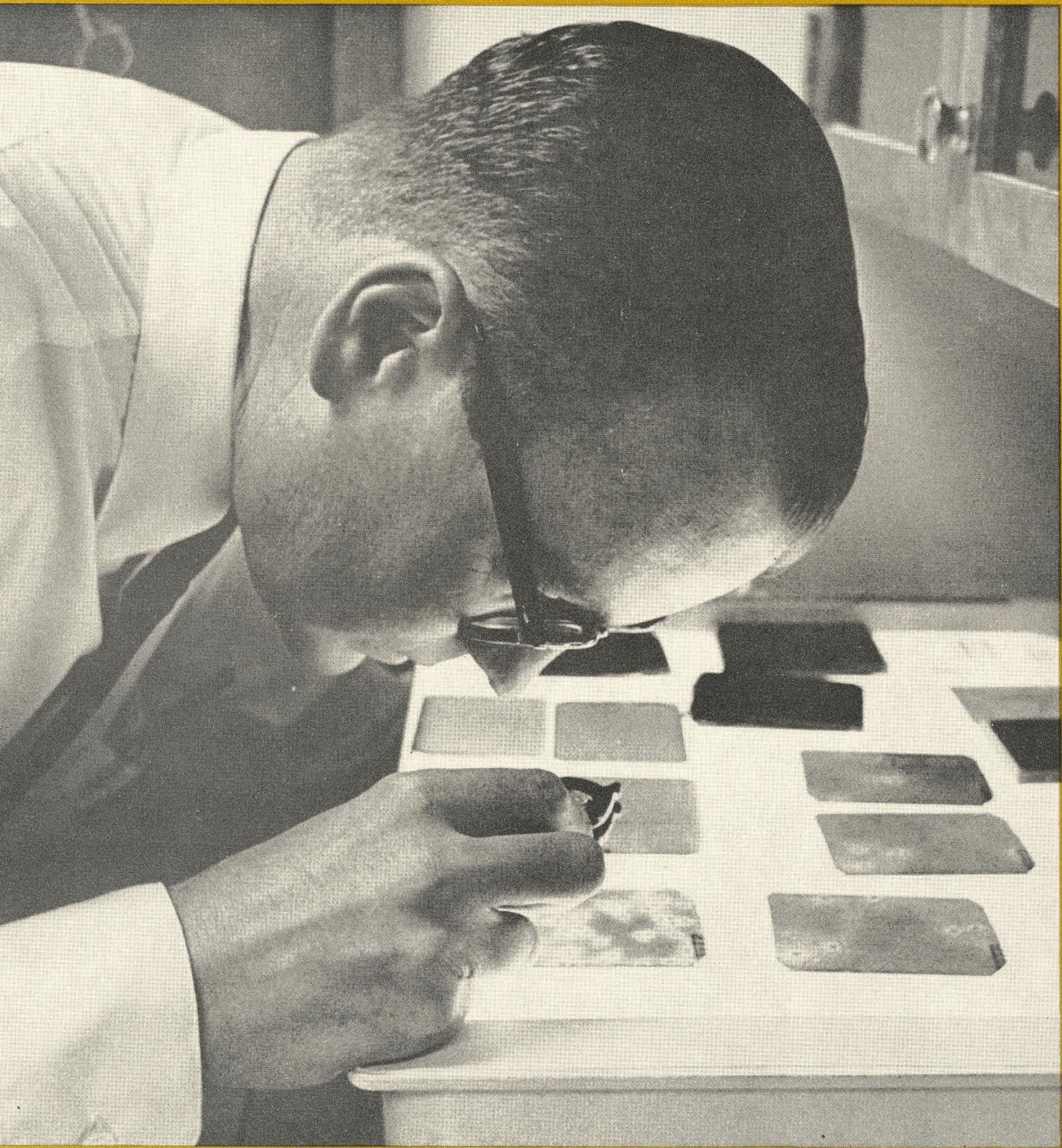
ENGINEERING | AND | SCIENCE

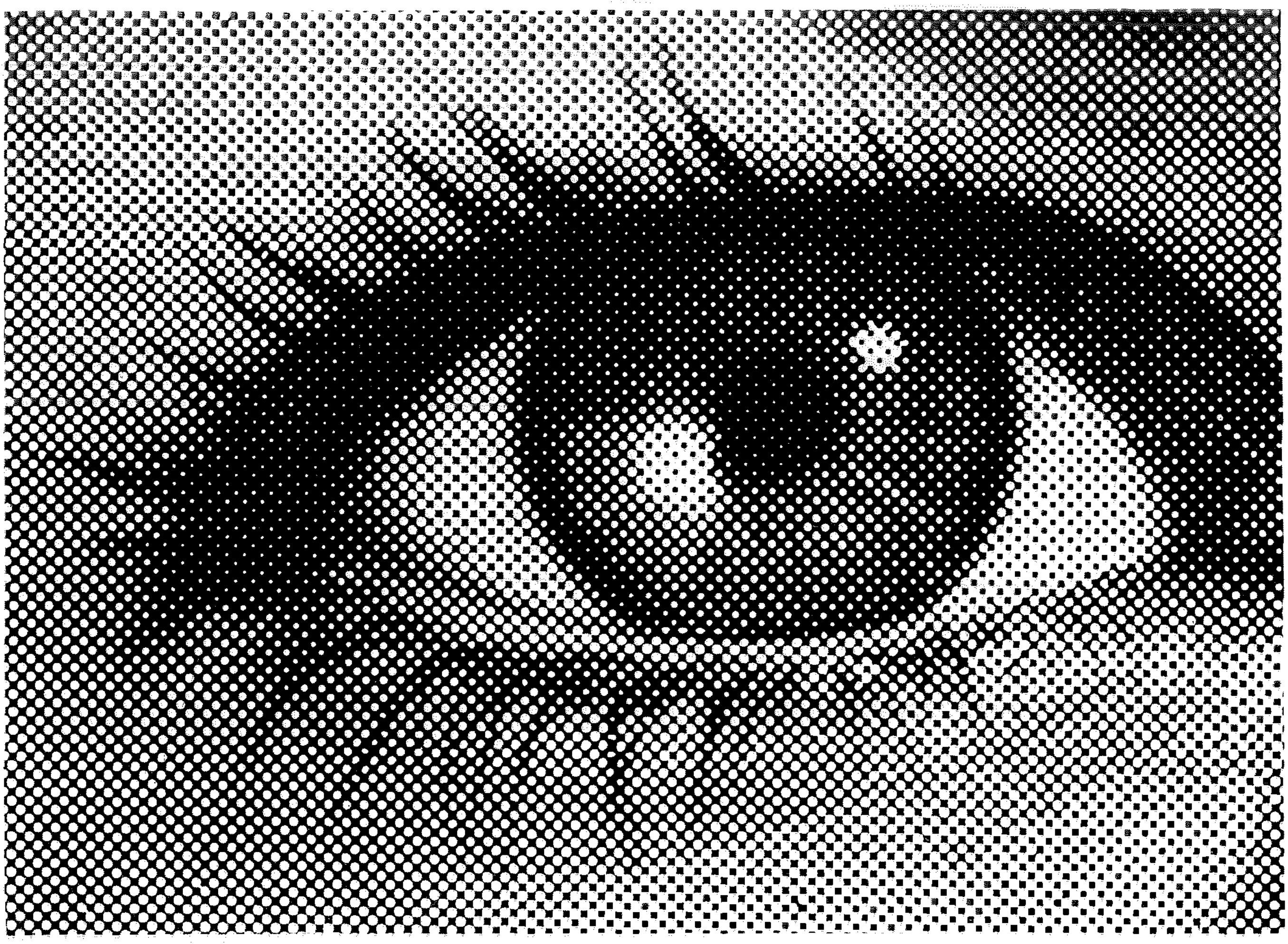
February 1962



Molecular Biology . . . page 16

Published at the California Institute of Technology

Want to see a pinhead cover 250 square miles?



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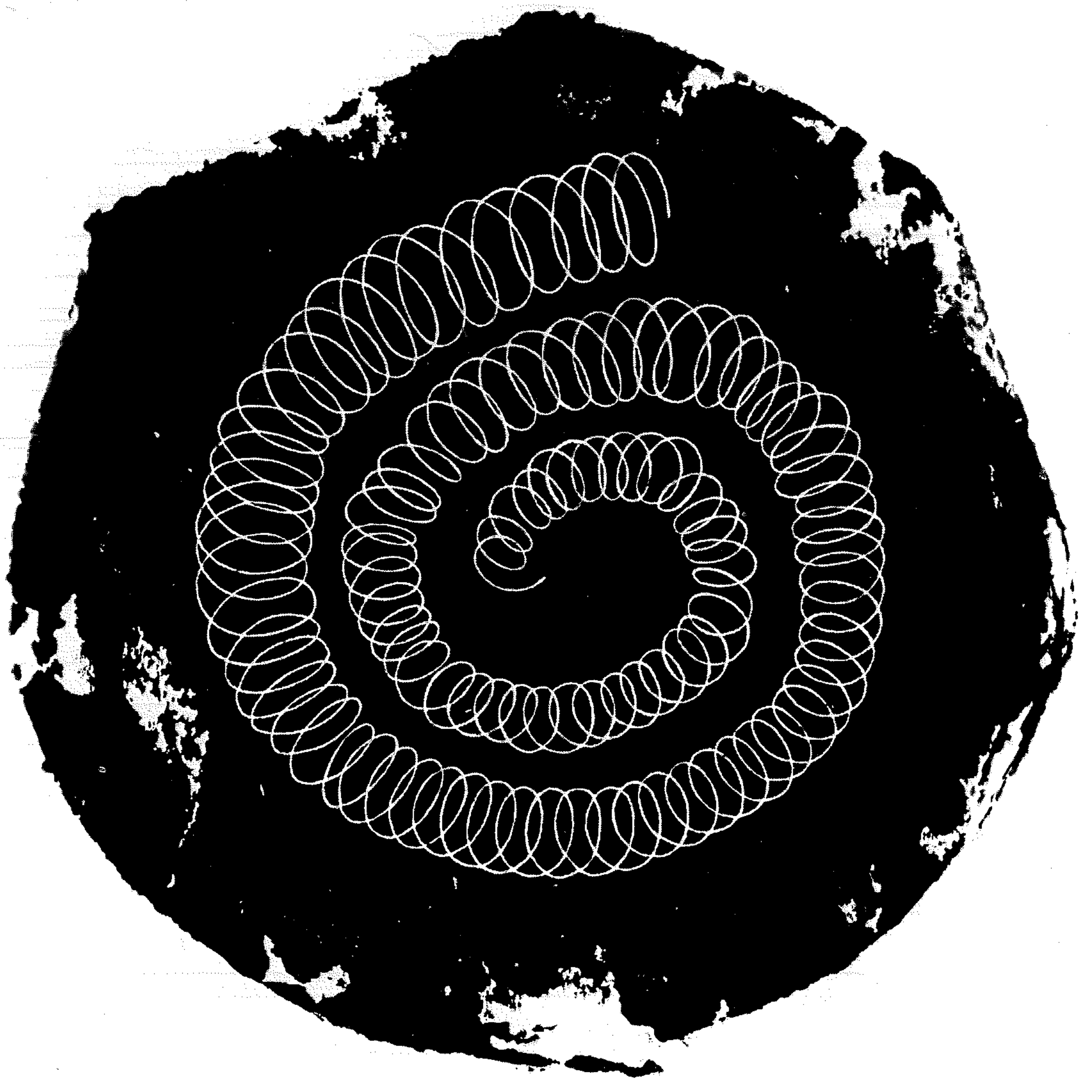

ENGINEERING AND SCIENCE

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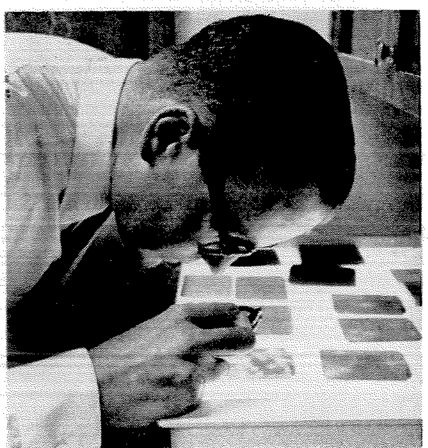

On Our Cover

–Alan J. Hodge, professor of biology, studies a negative taken with one of the three electron microscopes in the Institute's new Gordon A. Alles Laboratory for Molecular Biology. These microscopes, which are up to 200 times more powerful than the best optical microscope, enable biologists to examine the ultrastructure in the cells of higher plants and animals, and also in many viruses.

Dr. Hodge, a graduate of the University of Western Australia, was a member of the chemical physics section of Australia's Commonwealth Scientific and Industrial Research Organization for several years. He received his PhD from the Massachusetts Institute of Technology in 1952, and served as research associate in the biology department there. In 1960 he came to Caltech to develop the new laboratory of electron microscopy in the Gordon A. Alles Laboratory for Molecular Biology. On page 16, a pictorial report on current work in this laboratory.

"New Applications of Algebra"

on page 20, was originally given as a talk by Marshall Hall, Jr., professor of mathematics, to high school students visiting the campus on Students' Day, December 2, 1961.

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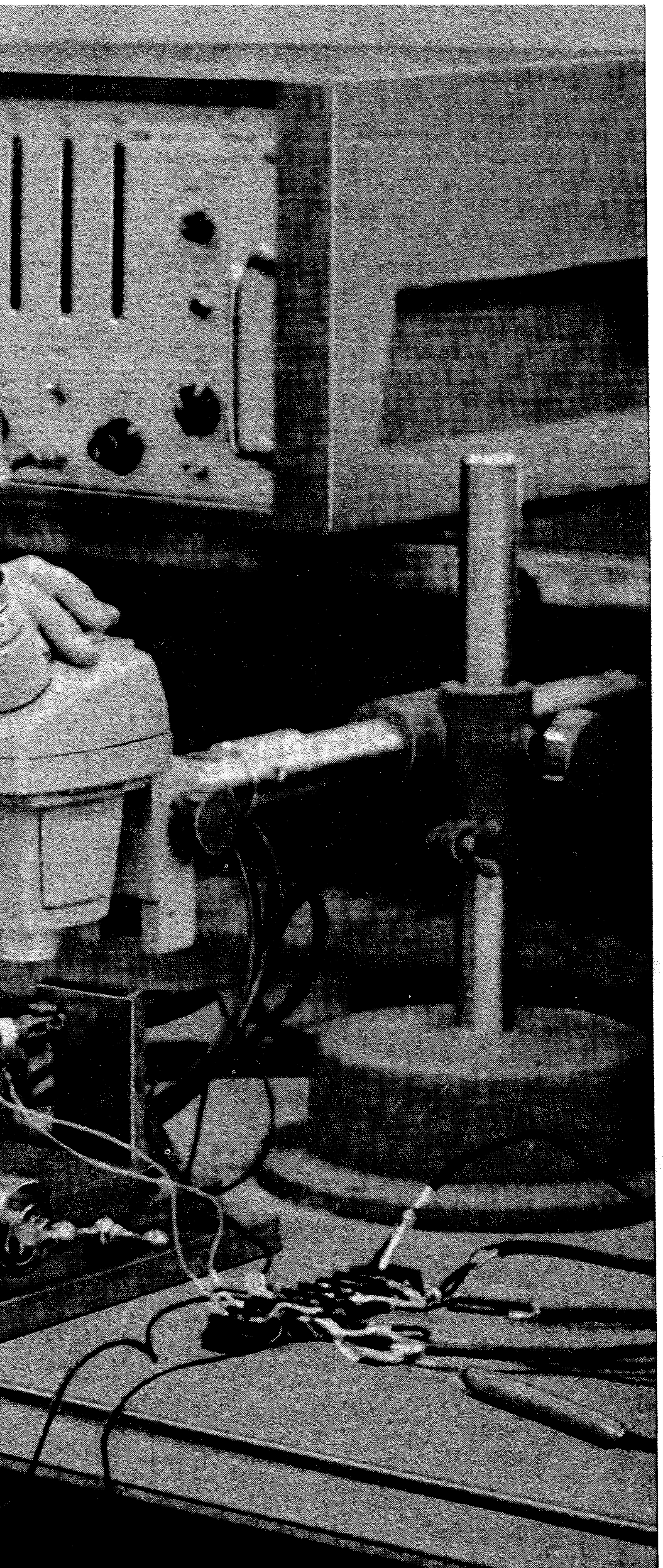

Peter R. Schulz (B.S. in M. E., Lehigh University '58) is a project engineer in the Manufacturing Research Laboratory where he's developing new techniques to improve manufacturing.

HE PUTS RESEARCH TO WORK ON THE PRODUCTION LINE

Examining new phenomena in cryogenics, optics, information theory, data communications and photochemistry, IBM research engineers and scientists are developing new concepts for information processing.

Some of these developments have a far-reaching, fundamental influence on basic knowledge, while others may have a more immediate application to actual problems. Where technological advances have a specific bearing on data processing needs, they must be considered for application in manufacturing. At IBM, that's a job for Manufacturing Research.

As a project engineer, Peter R. Schulz has found Manufacturing Research a challenging and rewarding assignment. Translating today's scientific discoveries to meet tomorrow's production line needs is an important step in creating exciting new products. It requires imagination and ability to put new techniques, equipment and processes to work on the production line.

At IBM, Manufacturing Research is an area of activity that provides as much room for professional growth and advancement as the engineer is ready for. In his three years with the company, for example, Peter Schulz has already received three promotions to reach his present position of responsibility. But no matter what your field of interest may be, IBM facilities and professional guidance provide plenty of backing for building a rewarding career.

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Books

The Dragon of the Ishtar Gate

by L. Sprague de Camp '30
Doubleday $4.95

Reviewed by Harvey Eagleson, professor of English

It is an odd, interesting and amusing experience to review a novel by a man whose undergraduate themes I read and corrected, and with whom I took my first trip into the desert. (Imperial Valley, yet!) Because of these circumstances, what I am about to write is probably more interpretation than critical analysis. Sprague's new novel, *The Dragon of the Ishtar Gate,* is a story of adventure and high derring-do taking place in a romantic period (the reign of the great Persian king Xerxes, 486-465 B.C.) and in exotic places (the Middle East and the Valley of the Nile). It is not a plotted novel like *Ivanhoe* or *The Three Musketeers,* but a picaresque novel like *Gil Blas,* in which the hero engages in an episodic series of adventures, frequently interrupted by interpolated narratives usually told by minor characters. Sprague's novel runs true to type and is related with dash and suspense. The book is worth reading if only for the story.

But the novel has other aspects which to me are more interesting than the story. It has a wealth of detail, some of it gruesome, concerning the clothes, buildings, food, manners, and customs of the various peoples encountered in the adventures, though never so much as to clog the swift action of the story. These details are fascinating and illuminating. I know nothing about the period portrayed, but I know Sprague's delight in accurate and meticulous detail, and I am certain these matters are as correct as possible with what learning is now available. Certainly the scenery is right, as Sprague took all, or at least a large part of the journey which is accomplished by his principal characters.

Further, knowing Sprague's great interest in cryptograms and the double meaning, I suspect that more is intended, though not to be taken too seriously, than meets the eye. The novel is not only a picaresque novel, it is a quest story. The quest story is a well known category of narrative which was particularly popular in the Middle Ages, the stories of King Arthur's knights being the most famous examples. All quest stories have a common narrative thread. The hero sets out to accomplish some purpose, but must overcome a series of obstacles or temptations before he can accomplish his mission. Sometimes he is successful, sometimes not. Also, nearly all quest stories are allegorical. The hero represents Man, his purpose is Man's ideals, the obstacles those which prevent Man from attaining his ideals.

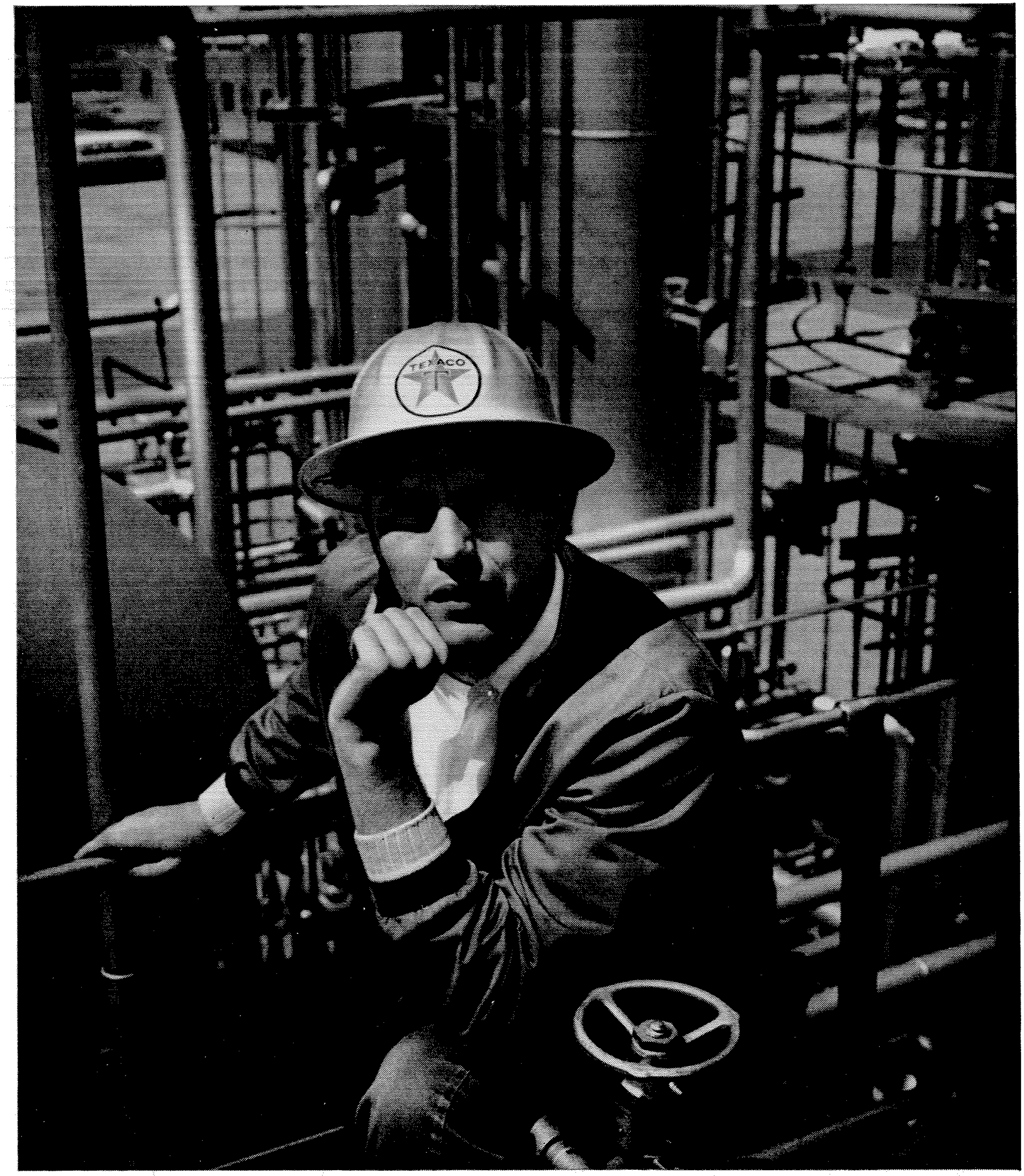
Sprague's story lends itself to this interpretation. The three leading characters, Bessas, Myron, and Kothar, represent three basic parts of Man's being, the physical, the rational, and the religious or superstitious. The river, of course, is the River of Life, the treasure of Takarta the idea toward which man struggles. In his struggle toward the ideal, he is aided under varying circumstances by either the physical, the rational, or the religious. But, as I interpret Sprague's fable, when Man reaches the ideal he will discover that the religious and superstitious, while it may have been useful at times in the past, is no longer useful but really misleading and treacherous, and so must be discarded.

"Childe Roland to the Dark Tower Came."

Peacetime Uses of Outer Space

Edited by Simon Ramo, PhD '36
McGraw-Hill $6.95

A symposium based on a series of public lectures presented by the University of California in 1960, under the direction of Simon Ramo, PhD '36, executive vice president of Thompson Ramo Wooldridge, Inc. The material is addressed to the intelligent layman, and the knowledgeable contributors include Lloyd V. Berkner, James H. Doolittle, Frederick R. Kappel, Vice Admiral John T. Hayward, Leston Faneuf, Leo Goldberg, Joseph Kaplan, Morris Neiburger, Willard F. Libby, Overton Brooks, Ralph J. Cordiner, Brigadier General Don Flickinger, and Edward Teller.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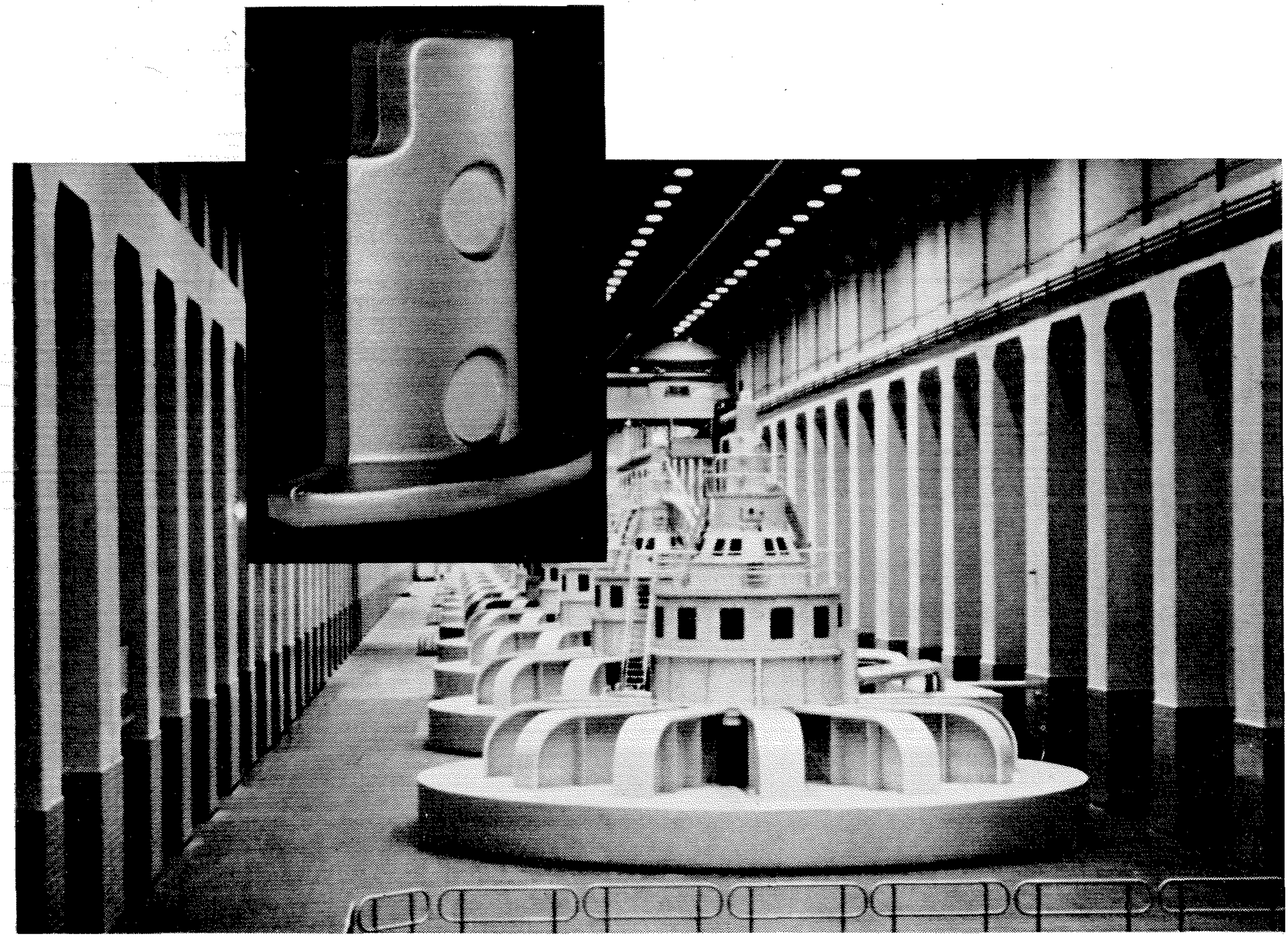


ENGINEERING AND SCIENCE
February 1962, Volume XXV, No. 5

THE SHAPE OF THE FUTURE

"Science deals only with things—not people."

But does it?

Some reflections on science, scientists, and the future.

by L. A. DuBridge

The fact that social and natural scientists seem to have little to say to each other is one of the tragedies of modern times. What is it that causes this gulf between the two worlds?

Many people will give you a pat answer. "Science," they say, "deals with *things;* social science deals with *people.*"

Well, aside from the fact that people and things have much in common (they are both composed of the same *atoms,* for example), the statement is simply not true. Does science deal only with things? Scientists study atoms and molecules; they study the earth, the planets, and the stars; they study about forces and energy and radiation; about genes and viruses and bacteria and cells. All *"things,"* you say. And so, in a sense, they are.

But there are two questions to ask: (1) Why do they study these particular things? and (2) How do they study them?

The answer to the first is easy: they choose things to study that *people* are interested in. That's silly, you may say; people aren't interested in atoms and crystals and stars and cells. Aren't they? Oh, yes, they are. And they'd better be. People have to inhabit this world — this universe. They are also *made* of atoms and molecules and cells. Everything they touch and handle is composed of the things the scientist studies. We are what we are because of the nature of the world in which we live.

Every act we perform, every thought we think, the very nature and structure of our bodies and minds themselves have been conditioned by the thousands of millions of years during which living beings have evolved on this particular planet. And eventually men became men — not because they were built of different molecules than other animals, but because man was equipped with a brain which could understand the physical world in which he lived, and, *understanding it, could adapt himself more perfectly* to it. And now men are on the verge of a better understanding of their own brains.

Man is a man because he observes, thinks, tries to understand things, and tries to make things useful. Man is a man, in short, because he is a scientist — because he studies the things that interest him and that may be useful to him, or may at least satisfy his curiosity.

Does science, then, have nothing to do with people? No — rather, science *is* people, people *thinking.*

How do scientists work? Well, they work like people too. They have curiosity; they try to satisfy it. They make mistakes, terrible mistakes. But they then discover their errors and try to correct them. They learn many things, and then they invent theories or laws or principles to correlate or explain their findings. They quarrel with each other about who is right or who is wrong about the theories of gravitation, or of atoms, of cosmology, heredity, disease,

"The Shape of the Future" has been adapted from an address delivered by President DuBridge at the inauguration of Dr. Henry David as president of the New School for Social Research in New York City on October 23, 1961.

or bodily functions. Human brains struggle mightily, trying to understand – and since they are human brains, their struggles to learn and to understand are limited by human prejudices, human experience, human failings. But they struggle on because they also have intense human aspirations, yearnings, and ideals.

The presumption that a scientist deals solely with a group of objective facts which he discovers about the physical universe is only part of the story. He must correlate and understand those facts, and he must also select from all the possible facts the particular ones that are of interest to him. These are truly creative processes; so his human interests, failings, limitations, desires, and capacities are a controlling element in his creative achievements. But also controlling are his human senses of beauty and order; his human instinct to know and to understand; his faith that the world can be understood.

Science—an intensely human undertaking

Science is an intensely human undertaking, involving not only the personal qualities of individual scientists, but a vast amount of communication, cooperation, and even conflict, between scientists. Scientists are people; they work and live and often fight as people. And they enjoy the human capacities and suffer from human frailties just like other people. Science is, in short, a social activity – and in a modern society it is a very important social activity.

Is social science, by contrast, exclusively a study of people? Granted that its objective is to understand how people behave, it must clearly take into account the fact that human activities, human living, and human relations are enormously affected by what human beings *are* and what they *know*. And what they know about the physical world and about themselves, and how they use this knowledge, is determined by the progress of science and technology.

Can anyone pretend that sociology, economics, philosophy, psychology, literature, history, or any other field of the humanities or social science has been unaffected by advances in scientific knowledge? Quite the contrary, our whole civilization, our whole social and economic system, our culture itself, is conditioned by such knowledge. Has not our whole social environment been radically altered by the telephone, the automobile, by radio and television? Has not the whole political environment been revolutionized by nuclear fission and fusion?

It may be said that none of these things has changed human nature itself. Men still write poetry and plays, love their wives and families, quarrel with neighbors over the back fence, brag about their own grandchildren and criticize everyone else's – just as they have always done. But the family arguments today often center around who gets to use the car, or which TV program we shall watch.

All our activities are affected by technology.

An international crisis arises and the world's statesmen are instantly on the phone, and the next day are meeting personally in New York, London, Geneva, or Berlin.

Oldtime educators wring their hands because colleges no longer teach Latin and Greek – to students who want to learn about electronics and space.

A thirty years' war is now unthinkable – and we wonder if the next war will last thirty minutes!

A major battle of the War of 1812 was fought weeks after the peace treaty had been signed, but before the news of the war's ending had crossed the Atlantic.

The point is obvious: the social scientist who believes that science and technology have no bearing upon human beings is as obsolete as the dodo.

Conversely, the scientist or engineer who is unconcerned with the social implications of new discoveries and new inventions is equally obsolete.

That last statement may surprise you, for it is a common aphorism that scientists and engineers carelessly toss out their discoveries to a waiting, or unsuspecting, or even unwilling world with no thought of what the consequences may be.

Discoveries and consequences

There is some truth in this. When a wholly new discovery in basic science is made, the scientist can't possibly ask himself what the social consequences of his discovery will be before he makes it. No one knows whether, or when, he is going to turn up a new idea or a new fact. Nor can he have any idea what it will be and, still less, whether it may have any applications, useful or precarious. Even after he makes his discovery, its applications are usually wholly unknown or obscure. The men who created the theory known as quantum mechanics could not have dreamed that this would lead to a revolution in the chemical industry, to a whole new era in transistor electronics, to computer machines that stagger the imagination with their speed and potentialities – much less to an understanding of atomic nuclei which led directly to practical attainment of nuclear energy devices.

Similarly, Einstein, back in 1905, could not possibly have foreseen the consequences of his relativity theory, either in an enlarged understanding of the universe or in the creation of atomic bombs. Nor could any one of the other thousands of physicists, mathematicians, chemists, biologists, or geologists who in the past one hundred years have contributed to a vastly increased understanding of the physical world have anticipated how his discovery could have contributed – along with others not yet made – to any discernible impact on society as a whole.

The engineer or applied scientist may be in a slight-

Shouldn't the scientists have refused to make an atomic bomb?

Should they now refuse to make other new weapons?

ly different position. He is seeking to use existing scientific knowledge to develop devices which will be useful to people or to society. In general, he concentrates on those matters which he believes, or his company believes, will be of human value — and which will thus find a large market. Surely, then, the engineer or inventor owes it to society to reflect on how his new creation will affect the society which uses it.

The engineer often does. In fact, I think one can say today that he *usually* does. The engineer directing a research project in industry normally believes sincerely, and usually correctly, that his project — be it better automobiles or telephones, or television sets, or airplanes or washing machines, or electronic computers — will benefit humanity at large. And he takes pride in contributing to such benefits. That's why he is an engineer rather than something else. He is concerned about the social impact of his work; and he wants the result to be good, not bad.

Unforeseeable consequences

No matter how much he tries, however, the inventor cannot foresee *all* the social consequences of his products. Henry Ford deeply believed that cheap family transportation would enormously benefit most Americans. And so it did. But could he have anticipated that he would change radically the pattern of metropolitan living, that his automobiles would eventually so jam our city streets that it would be faster to return to walking? Could he have foreseen the development of a whole new industry to manufacture gasoline and oil for his gas-buggies, another industry to make steel, yet another to make rubber for tires, and still another to build the roads and highways that millions of cars would need? Could he have foreseen that someday a labor stoppage in Detroit could nearly paralyze the economy?

Neither Henry Ford nor anyone else could have foreseen all this. And even if he had, what would he have done — destroyed his invention, only to let someone else make all that money? And who is to say whether the net result has been good or bad?

But I have been giving only examples of so-called peaceful inventions — things that looked (at first, at least) as though they would *benefit* people, not kill them. Of course, the automobile has killed more people than most of the wars between nations ever did, but that's an unforeseeable consequence too.

How about those who purposefully and energetically set out to make new weapons of war. Couldn't they have a little more consideration for human life and human welfare and international relations? Shouldn't the scientists, for example, have refused to make an atomic bomb? Should they now refuse to make other new weapons?

The answer to that is fairly easy. The men who made the atomic bomb were not sadists. I know many of them very well. They are men who knew in 1942 that America was in grave peril — and so were all the ideals which Americans had always fostered and cherished. They would have been less than human, certainly less than patriotic, if they had not been both willing and anxious to contribute to America's defense. Many of them knew the potential consequences of the Bomb — and feared them. But they feared even more the consequences of defeat by the Axis powers. And today they fear still more the consequences of defeat by Soviet Russia. Either defeat could have meant the death of freedom. And if freedom must be protected by force, it is essential that the forces available to free nations be adequate for the task.

While scientists and engineers work to keep America's defenses adequate, they also in great numbers and with great energy try to persuade the peoples of the world that war is obsolete, that these weapons should never be used, that peaceful ways to solve international disputes must be found.

Unforeseeable benefits

Their success in this endeavor has, as yet, not been too startling. And the scientists have set off some pretty bitter controversies in their efforts. But such efforts must be made, and in a new era of human relations, controversies on method are bound to occur. All the more reason for all men of good will to join together and devote their best efforts to this task. In some ways, atomic weapons have brought scientists, social scientists, businessmen, and politicians closer together than any other technical development in history. Maybe this is its most important consequence — an unforeseeable benefit.

My point, then, is this: Scientists and engineers do worry about the consequences of their work. But neither they nor anyone else has discovered how to avoid or even to predict these consequences.

So far I have been speaking of the past. What of the future? I should love to tell you all about the scientific discoveries that are about to be made and how they will be used, and what the social consequences of each will be. That is manifestly impossible for anyone. Yet some things can be said. Some new and important developments of great potential import have already taken place. Maybe scientists and social scientists would do well to ponder on some of the things already in sight.

What is in sight?

Automation—and problems

First, human manual labor – and indeed most routine nonthinking operations by humans – are soon to be obsolete. Oh yes, the housewife must still sweep the floors and scrub the children, men and women must still water the flowers and mow the lawn (with a power mower, of course). Houses must be painted, fields plowed, trucks driven, and so on.

But industrial processes, processes involving mass production, are more and more going to be carried on by machines, and the machines are going to be controlled by electronic devices. "Automation" many call it – a nasty word in many circles. But it's here and it's spreading fast. And when automatic machines can manufacture goods faster, cheaper, and better than by hand, they can't be stopped. In fact, they should be welcomed with loud cheers. Alleviation of hard labor is one of the most cherished dreams of mankind.

But there are problems. Men trained to perform only a certain kind of manual operation will face unemployment. How shall we cope with this? By preventing automation? Or by subsidizing the unemployed? Or by retraining them to do other jobs? By moving them to other locations? Or what?

Here is a prime example of the social consequences, just emerging, of a new technological development. I commend it to you for study. But don't confine the study to berating the technological development. Rather, let's first understand it, evaluate its values and its dangers, examine the human and economic problems that may evolve, perform limited experiments to learn the possibilities and problems of retraining, redeployment, or relief. And also ask the question whether, in the nation as a whole, the long-time benefits will be great or small, and to what extent they justify strenuous and expensive measures to avoid any inevitable human suffering.

We have entered the space age. During the next 10 or 20 years – probably for the next 100 or 1000 years – we are going to be spending several billion dollars a year to send instruments and men into space, to land on the moon and later, on the nearby planets, Venus and Mars. Still later, we shall go to the far reaches of the solar system.

What social consequences will result? Only a very few are clearly discernible. We shall spend a lot of money and we shall create whole new industries. Will this stimulate economic prosperity, or will it destroy it by higher taxes? You will hear opinions on both sides. Is it possible to learn the truth?

Will the space results be worth the cost? Who can tell? Who can evaluate in dollars the worth of new knowledge, the value of human exploration, the importance of satisfying man's eternal yearning to break the chains that tie him to the surface of this planet and let him see what other worlds are like? And who can place a dollar value on keeping ahead of the Russians?

Will great new military power result from space exploits? Personally I think not, but I could be wrong. Will new materials be discovered on the moon or on Mars that will revolutionize life on earth? Again, the chances are vastly against it, but we can't be sure till we get there. Can the moon or Mars or another planet be used to establish colonies to siphon off the earth's excess population? As of now, the answer is assuredly *no*. Other planets are all but totally uninhabitable by human beings, and shipping off thirty million people a year in giant rockets seems unlikely to be a practical undertaking very soon.

What, then, does space exploration mean? Right now it means loads of money spent to attain new knowledge. How it will affect the way people live and act we can't yet imagine.

I commend the problem to you for study. However, please don't let the conclusion to your study be simply the statement that space is no damn good. Men are going there; they can't be stopped. The question is: How do we make the going yield the greatest benefits and the fewest sorrows?

Also, do not let the conclusion of your study be simply that the billions spent on space could be better expended in building roads or curing cancer, or studying the atom, or improving the social or behavioral sciences. If the space program stopped, that money would not suddenly be given to the New School, or to Columbia University, or to Caltech. That money is being appropriated for something that most people (or at least most congressmen) believe is important. It is not automatically transferable to other items. Those other items must be presented to Congress on their own merits. A ten-billion-dollar appropriation for cancer would not result in a sure cure. We don't know enough to spend it. We *do* know enough to get into space. For better or worse, we have to concentrate on those things we know how to do.

A package of problems

The final problem I am going to suggest is really a package of problems. It is this: From a purely technical standpoint, we now know enough to do each of the following things—

1. Produce enough food to feed every hungry mouth on earth, and to do this even though the population should double or treble.

2. Make fresh water out of sea water and thus irrigate all the world's arid regions.

3. Revolutionize the transportation system in our cities, eliminating traffic jams and allowing everyone to go to and from his work with speed and comfort.

4. Transport large numbers of people or large quantities of material from any place on earth to any other in a few hours.

5. Produce enough energy from uranium to light and heat our homes and offices, electrify our railroads, and run all our factories and mills.

6. Build automobiles, washing machines, houses, buildings, and a myriad of other devices and structures which will last under hard use not one or two or five to ten years, but 10 or 50 or 100 or 500 years.

7. Establish instantaneous communication by telegraph, telephone, teletype, or television between any two points on the face of the earth – and indeed, when the occasion arises, between any two points of the solar system.

8. Rid the air of our cities of all forms of man-made pollution.

9. Build houses, buildings, and whole cities which are essentially weatherproof – heat-proof, cold-proof, and storm-proof – and make every city as nice as California!

I assure you that all of these things, and many more I have not named – are technically feasible. A few, as you know, are now being done on a small scale. Why don't we do them all on a big scale, and thus solve a host of the world's problems?

There is just one small difficulty. Money!

A matter of money

Every one of these things I have mentioned, though now technically feasible, is far too costly to be undertaken except in limited circumstances, and some are too costly to be undertaken at all. It is true that further technical developments and discoveries may make some of them cheaper some day. But right now a host of techniques capable of solving mankind's problems and easing his burdens cannot be used because we do not know how to bring adequate resources of money, labor, and materials to bear on the problems – or bring them to bear in such a way that the results achieved would, in a monetary sense, justify the costs. There is no present hope that any one of the nine items I mentioned will be economically feasible.

It is technically feasible, for example, to irrigate all the western deserts in the United States with distilled sea water. But the cost would be so tremendous that the value of the extra food produced – even though it may be desperately needed, say, in India or Burma or Africa – would not begin to pay the annual operating costs. And this is true no matter whether private or public funds are used. This situation might change if the costs of rectified sea water go down or the price of food goes up. But, as of today, and apparently for many years to come, it is just not economically justified. The same is true of uranium energy, of rapid metropolitan transport, and all the rest.

Is there a solution to this economic dilemma? I don't know, and I'm afraid I don't even believe it can be solved by economic or social measures alone. Nor do I now see any technical solutions either. I may, however, be too pessimistic.

But I suggest it is a challenging problem.

Finally, let me point out only too briefly that all mankind is faced with one overpowering problem: *ignorance.* And I don't mean lack of education – although there is plenty of that too. I mean that men are just plain ignorant. No one knows how to make men live to be 150 years old; no one knows precisely what holds the atomic nucleus together; no one knows how big the universe is or how it evolved; no one knows how to persuade men to live together peaceably on the only planet we now have; no one knows how to stop crime, to run a democratic government more effectively, to avoid economic depressions, to eliminate unemployment, or to finance our schools and colleges adequately.

Why, we are so ignorant we don't even know all the things we don't know! Our island of knowledge in the vast sea of ignorance is so tiny we wonder whether it may not be wholly engulfed.

So what shall we do?

The fight against ignorance

First: Let's not be discouraged. This earth has existed four billion years and will probably last another four billion. Human beings began to learn how not to be so ignorant only a few thousand years ago. Maybe a few million years hence we may have learned quite a lot.

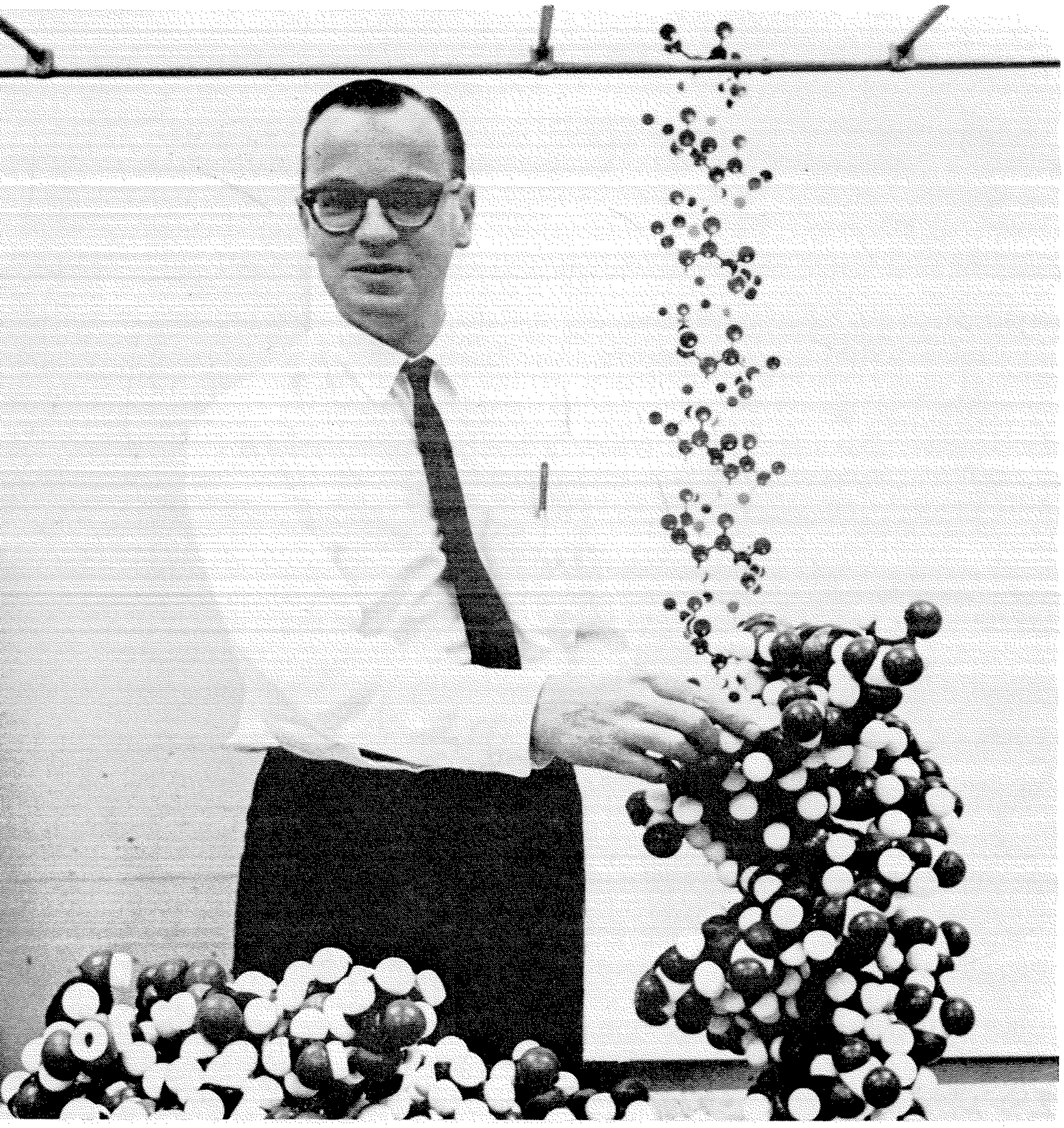
Second: Let's spend more effort on learning. We may be terribly ignorant, but we don't have to stay that way. We at least have learned how to learn – slowly and inadequately perhaps, but we have made progress. If only we took the learning process a little more seriously, we could learn even faster. Most of the people in the world don't want men to learn more, or don't think it is important.

But thousands or millions of men and women around the world do. And they are going to keep on encouraging and supporting the fight against mankind's ignorance because they know it is the most important thing on earth.

That is why thousands of centers of learning throughout the world exist. They are the essential outposts in this quest for more knowledge in all fields.

"Seek ye the truth – and the truth shall make you free."

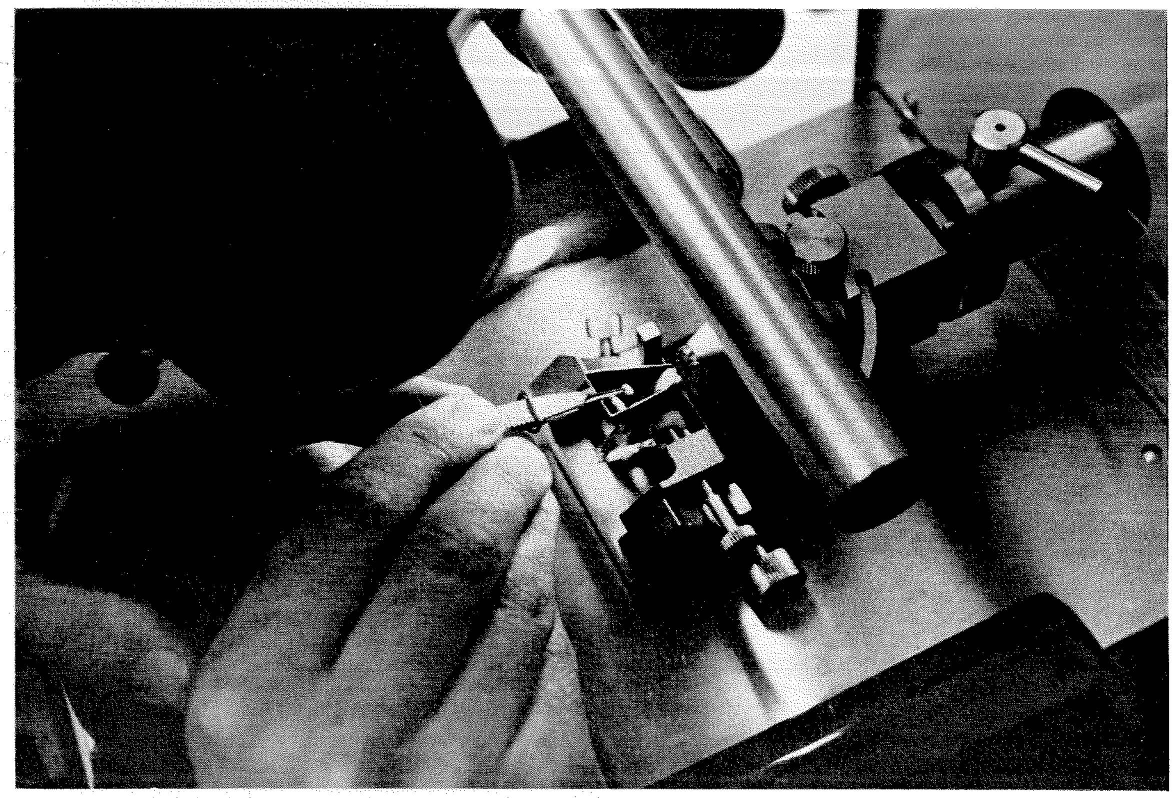
No more important injunction was ever enunciated to the human race.



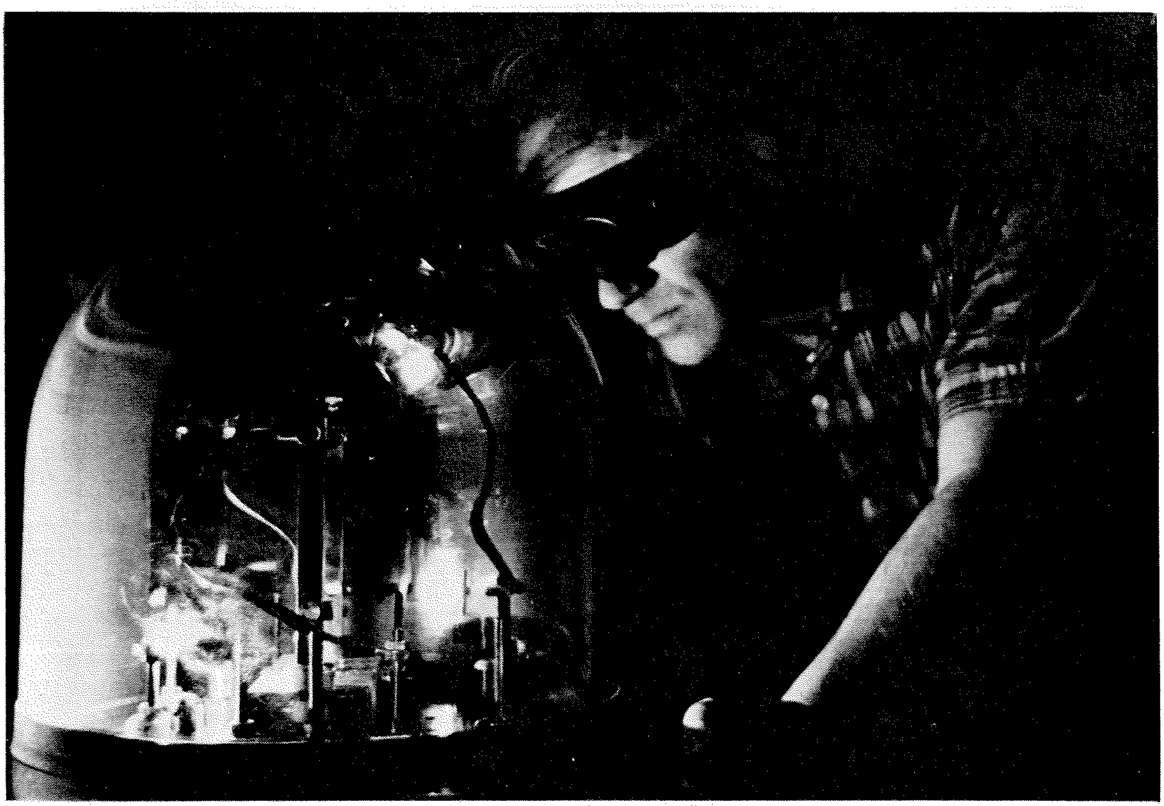
Alan J. Hodge, professor of biology, and the foam plastic models used to study the structures and interactions of complete proteins and portions of the helical structure of DNA—which Dr. Hodge works with here. The atoms in this structure are magnified 125 million times. DNA is one of the nucleic acids which carry and transmit the coded information of heredity. Research at Caltech, plus an accumulation of material from other laboratories, may soon allow biologists to crack the code by which chemical molecules control the processes of life.

MOLECULAR BIOLOGY

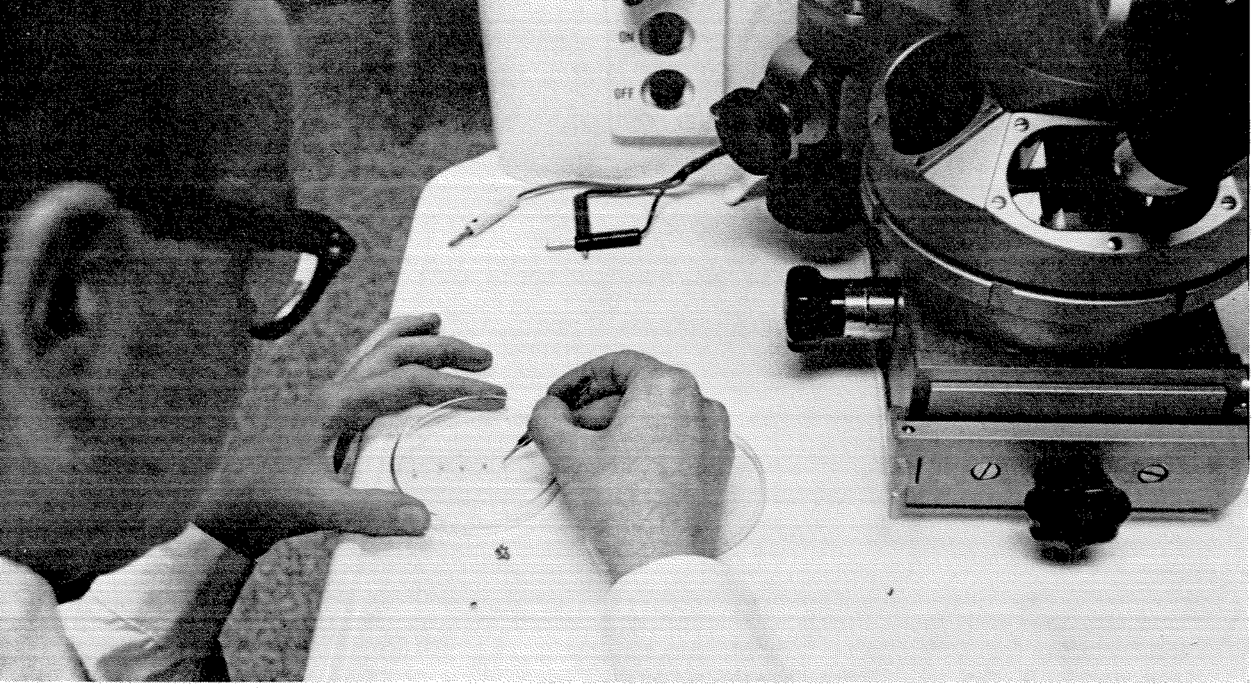
Molecular biology — which deals with the nature of molecules that are important to living systems, their forms, functions, and organization — is one of the active research areas in Caltech's biology division Much of this research is carried out in a new laboratory of electron microscopy, housed in the Gordon A. Alles Laboratory for Molecular Biology. Here, three highly critical electron microscopes and many supporting instruments are helping to open up the world of ultrastructure in the minute cells of higher plants and animals, and also in many viruses. On these pages, a pictorial report on current research in the new laboratory.



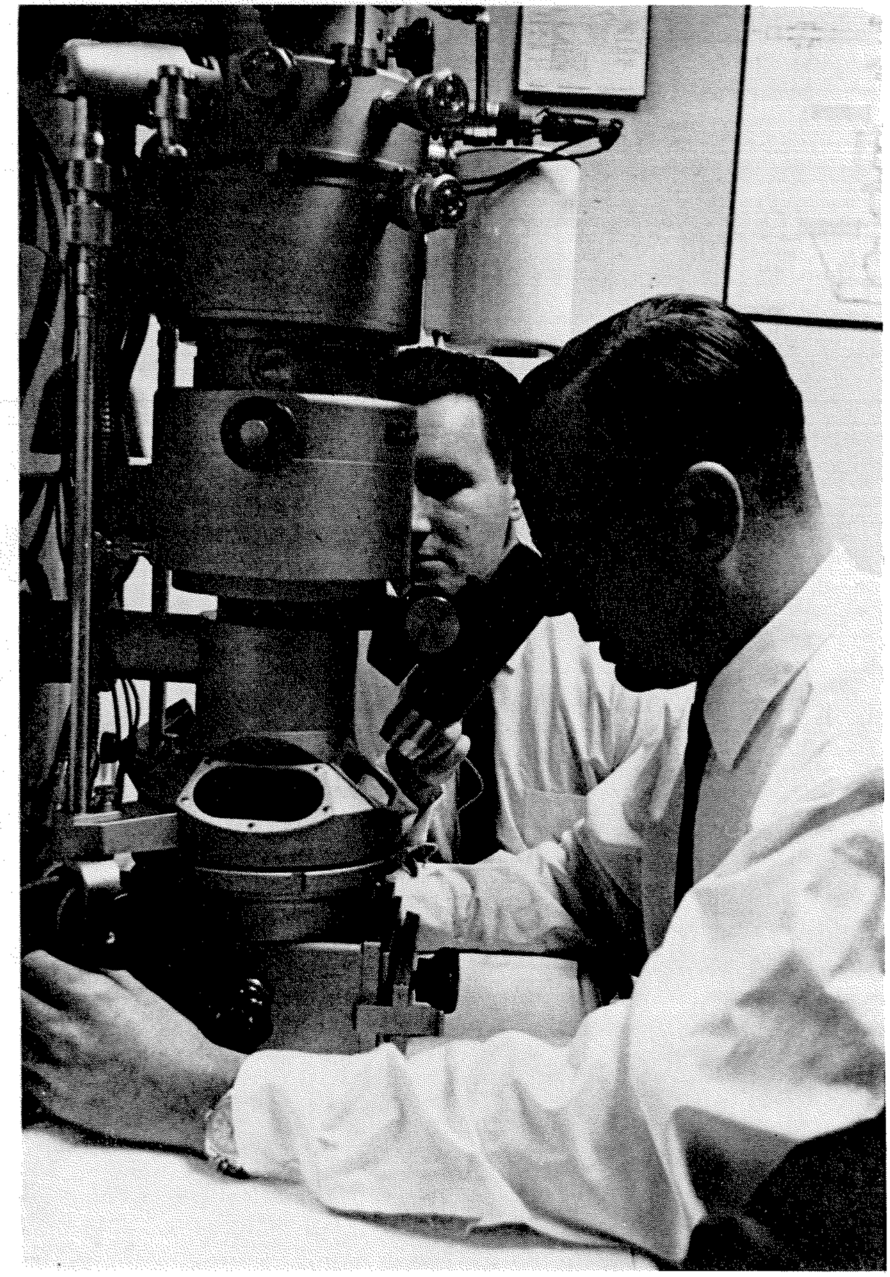
In the new laboratory an ultramicrotome is used for cutting ultrathin slices of tissues embedded in clear plastic. The machine cuts slices of tissue less than half-a-millionth of an inch thick.



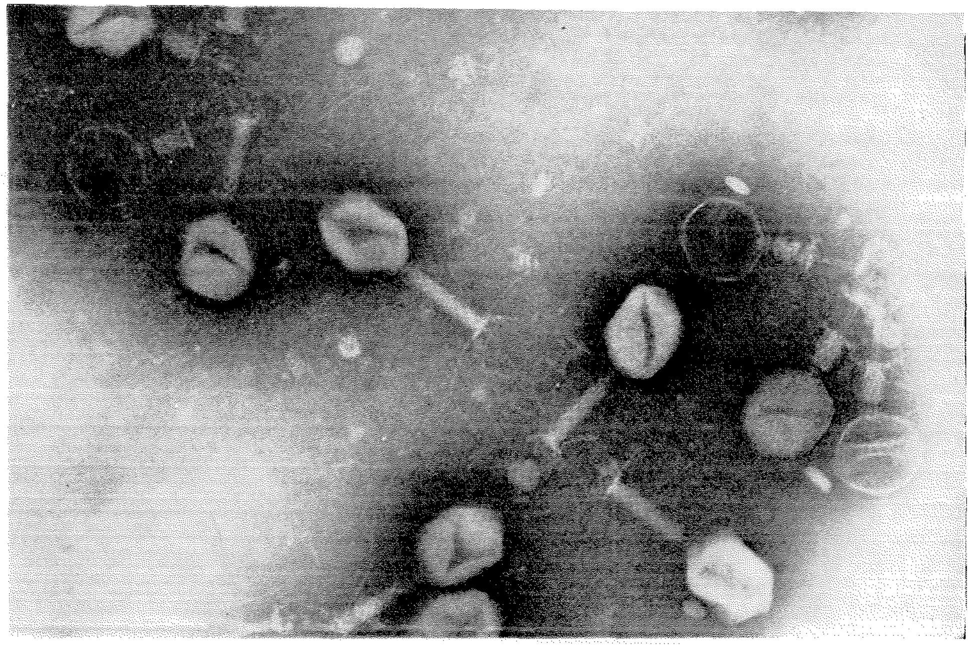
Before viruses or thin slices of tissue can be photographed with the electron microscope, a thin film of carbon must be deposited in this vacuum evaporator in order to support the specimen. Here, too, thin films of heavy metal elements are sometimes deposited on the specimens to enhance contrast in the negatives.



The very thin, almost invisible, slices of tissue on their supporting grills, shown here in a petri dish, are put into a special holder and cap, which can be seen just below the dish. The holder is then inserted into the electron microscope for photographing.

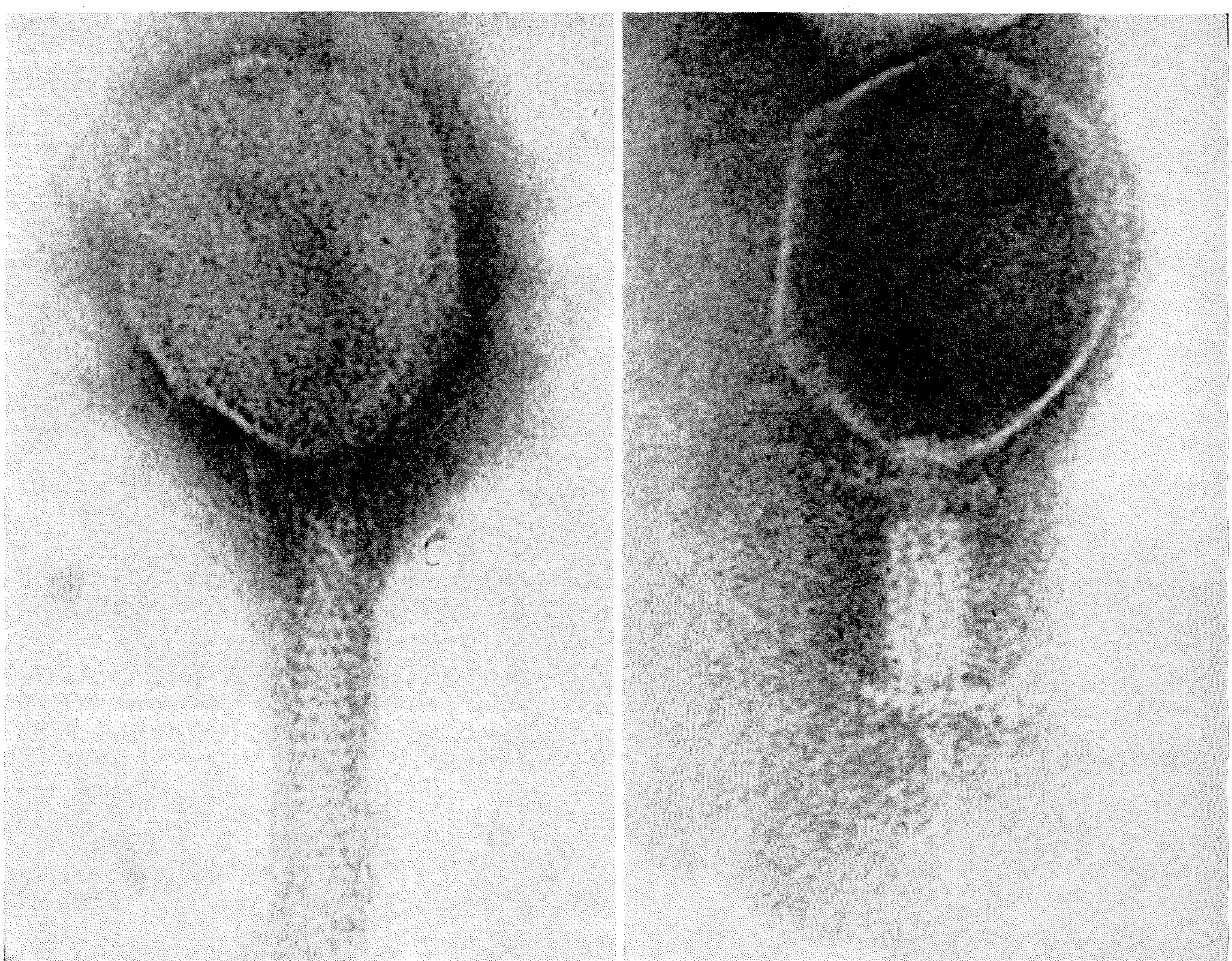


The electron microscope is capable of photographing details of structure more than 200 times smaller than are visible in the best optical microscope. It is used not only for study of tissues, but for a wide variety of other projects, such as investigations on the fine structure of viruses, the membranes, and many other components of cells.



An electron microscope photograph of one of the many viruses studied in the laboratory. This is an interesting one identified as T-4, here magnified 100,000 times. T-4 possesses a remarkably complicated structure, including a highly specialized tail which has a hollow core surrounded by a contractile sheath, and a baseplate with fibers. The head is filled with DNA.

The T-4 virus, magnified even more, shows the structure plainly. Infection of the host cell by T-4 is thought to occur when the tail attaches to the cell by means of the fibers. The tail sheath then contracts, causing penetration of the cell wall by the hollow core. DNA flows from the head, through the core, into the cell. At the left, an intact virus particle; at the right, the DNA has passed through the core, leaving the head empty. The DNA, having entered the cell, then reorganizes the cell machinery to manufacture 100 or more copies of the complete virus.



New Applications of Algebra

A mathematician solves some typical, practical, present-day problems — and thereby proves that algebra is doing better than holding its own in modern technology.

by Marshall Hall, Jr.

A friend of mine has observed that there are certain "OK words" whose use imparts a favorable impression. With this in mind he has written a book about computers called *Dynamic Programming*, since the word "dynamic" is filled with all kinds of desirable connotations. I shall take my cue from him and begin with "Algebra of the Space Age," since an application to "space" provides status and modernity to anything so dignified.

Signals coming back to earth from a satellite will be a succession of dots and dashes which we may represent algebraically by a succession of zeros and ones. It is to be expected that reception of a signal coming from millions of miles away will not be perfect. Nevertheless, if the different words produced differ from each other sufficiently, an error in reception of one or two dots or dashes in a word will still leave the receiver with no question as to which the original word was. This is known as the problem of constructing "error-correcting codes" and has been studied extensively.

An example of such a code is the following set of 24 words, each consisting of 12 zeros or ones, with the property that any two of the words differ in at least 6 of the 12 places:

Column number	∞	*0*	*1*	*2*	*3*	*4*	*5*	*6*	*7*	*8*	*9*	*10*
W_1:	1	1	1	1	1	1	1	1	1	1	1	1
W_2:	1	0	1	0	1	1	1	0	0	0	1	0
W_3:	1	0	0	1	0	1	1	1	0	0	0	1
W_4:	1	1	0	0	1	0	1	1	1	0	0	0
W_5:	1	0	1	0	0	1	0	1	1	1	0	0
W_6:	1	0	0	1	0	0	1	0	1	1	1	0
W_7.	1	0	0	0	1	0	0	1	0	1	1	1
W_8:	1	1	0	0	0	1	0	0	1	0	1	1
W_9:	1	1	1	0	0	0	1	0	0	1	0	1
W_{10}:	1	1	1	1	0	0	0	1	0	0	1	0
W_{11}:	1	0	1	1	1	0	0	0	1	0	0	1
W_{12}:	1	1	0	1	1	1	0	0	0	1	0	0
W_{13}:	0	0	0	0	0	0	0	0	0	0	0	0
W_{14}:	0	1	0	1	0	0	0	1	1	1	0	1
W_{15}:	0	1	1	0	1	0	0	0	1	1	1	0
W_{16}:	0	0	1	1	0	1	0	0	0	1	1	1
W_{17}:	0	1	0	1	1	0	1	0	0	0	1	1
W_{18}:	0	1	1	0	1	1	0	1	0	0	0	1
W_{19}:	0	1	1	1	0	1	1	0	1	0	0	0
W_{20}:	0	0	1	1	1	0	1	1	0	1	0	0
W_{21}:	0	0	0	1	1	1	0	1	1	0	1	0
W_{22}:	0	0	0	0	1	1	1	0	1	1	0	1
W_{23}:	0	1	0	0	0	1	1	1	0	1	1	0
W_{24}:	0	0	1	0	0	0	1	1	1	0	1	1

If our reception of a word is such that two errors are made, then by changing two of the characters received in all possible ways we find our original word and words differing from it in, at most, four places—the two which were wrong to start with, and the two which have been changed. But, in this way, we cannot obtain any other of the 24 words since any two differ in at least six places. With three errors the situation is different. For example, the word

$$W \quad 1 \; 0 \; 0 \; 1 \; 1 \; 0 \; 0 \; 0 \; 0 \; 0 \; 0 \; 0$$

differs from W_{11} in three places, and from W_{12} in three other places. It also differs from W_{13} in three places. We can detect the fact that there are at least three errors, but we cannot decide with certainty which the correct word is. We say that the 24 words above form a two-error correcting, three-error detecting code.

What is the underlying algebraic theory of this code? The first twelve words are such that any two differ from each other in exactly six places. The last twelve are complements of the first twelve, obtained by interchanging zeros and ones throughout. In general, if we can find n words of length n with any two agreeing in n/2 places and disagreeing in the other n/2 places, by taking complements we will have a code of 2n words of length n. This code will correct anything less than n/4 errors and will detect errors of n/4. Thus our problem is to construct n words differing from each other in exactly n/2 places. Obviously n must be even. For $n = 2$ we have

$$\begin{matrix} 1 & 1 \\ 1 & 0 \end{matrix}$$

satisfying our requirements. When n is larger than 2, it turns out that n must be a multiple of 4. The number of agreements and disagreements between rows is not changed if we interchange zeros and ones in a column. Let us do this so that the first row consists entirely of ones. Then the first three rows will have a pattern of the following type:

$$\begin{array}{cc|cc|cc|cc}
\multicolumn{4}{c}{\overbrace{\hspace{8em}}^{n/2}} & \multicolumn{4}{c}{\overbrace{\hspace{8em}}^{n/2}} \\
1\,1 \cdots & 1 & 1 \cdots & 1\,1 & 1 \cdots & 1 & 1 \cdots & 1 \\
1\,1 \cdots & 1 & 1 \cdots & 1\,1 & 0 \cdots & 0 & 0 \cdots & 0 \\
\hline
1\,1 \cdots & 1 & 0 \cdots & 0 & 1 \cdots & 1 & 0 \cdots & 0 \\
\multicolumn{2}{c}{r} & \multicolumn{2}{c}{s} & \multicolumn{2}{c}{t} & \multicolumn{2}{c}{u}
\end{array}$$

A simple calculation shows that

$$\begin{aligned} r + s &= n/2, & t + u &= n/2 \\ r + t &= n/2, & s + u &= n/2 \\ r + u &= n/2, & s + t &= n/2 \end{aligned}$$

comparing the rows two at a time. From this it follows that $r = s = t = u$ and so $n = 4r$ is a multiple of 4. It is conjectured that every multiple of 4 may be used to form such a code. Methods developed in 1933 by R. E. A. C. Paley gave all multiples of 4 up to 88, and many further values, but not until a few weeks ago was a code developed for the number 92 using a high speed computer at the Jet Propulsion Laboratory.

The cyclic pattern of words W_2 through W_{12} above is easily seen. It can be described by using the prime number 11 and squares of positive numbers to place the five 1's (except for column ∞) by the rules

$$\begin{aligned} 1^2 &= 1 & &+ 0 \cdot 11 \\ 2^2 &= 4 & &+ 0 \cdot 11 \\ 3^2 &= 9 & &+ 0 \cdot 11 \\ 4^2 &= 5 & &+ 1 \cdot 11 \\ 5^2 &= 3 & &+ 2 \cdot 11 \end{aligned}$$

Thus, for W_2 we place 1's in columns ∞, 1, 3, 4, 5 and 9. In the same way, for primes 19, 23, 31, of the form $4r - 1$ we may use the same sort of rule to construct a code of 8r words of 4r dots and dashes. But to obtain 92 as a value for 4r a more complicated procedure was needed.

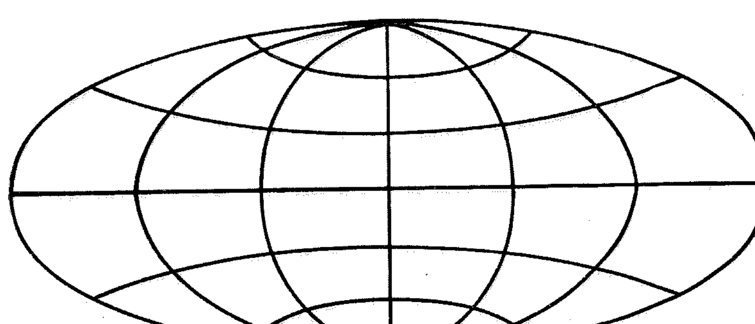
Military problems of logistics

This particular problem is a problem of arrangement and, as such, is a more sophisticated version of simple problems on permutations and combinations. Other problems of this kind which have been studied are military problems of logistics. For example, how shall we plan to send spare parts and other supplies to outer bases with the greatest expectation of satisfying all needs and yet proceeding economically? How can we schedule oil tankers to bring oil from the production centers to the centers of consumption, so as to make full deliveries with the minimum number of ships?

The assignment problem

As a final illustration of this approach I shall mention the assignment problem. This is the problem of assigning n men to n jobs, when we are given rating scores a_{ij}, i, j running from 1 to n as to the value of the ith man in the jth position, so as to make the sum of the scores for the selection as large as possible. These scores may be the result of competitive tests, or may be a summary of the opinions of superiors. The source of the scores is not our concern here, and for our purposes they can be any random assortment of positive integers. Here is a table of scores for 8 men and 8 positions:

continued on page 24



Positions (columns) / **Men** (rows)

Men	1	2	3	4	5	6	7	8
1	1	5	4	7	7	3	6	6
2	4	2	5	4	6	1	2	5
3	6	5	2	4	4	2	5	3
4	7	1	7	3	3	2	1	5
5	3	6	7	3	2	5	5	4
6	7	5	6	7	6	1	4	6
7	6	1	5	2	2	1	7	3
8	4	4	7	3	2	1	3	1

The method consists in using row numbers $r_1, \ldots, r_n$ and column numbers $c_1, \ldots, c_n$, such that in every case $a_{ij} \leq r_i + c_j$. This can certainly be done by taking all row numbers to be zero and taking c_j to be the largest value in the jth column. For any selection of n scores – one from each row and column – we certainly have $a_{1s} \leq r_1 + c_s \ldots, a_{nz} \leq r_n + c_z$. Hence $a_{1s} + \cdots + a_{nz} \leq r_1 + \cdots + r_n + c_1 + \cdots + c_n$ since every column is used exactly once. Thus our maximum selection score cannot possibly be greater than the sum $S = r_1 + \cdots + r_n + c_1 + \cdots + c_n$ for any choice of row and column numbers such that $r_i + c_j \geq a_{ij}$ for all i and j. It can be shown that if we cannot make a selection from those top scores a_{ij} which are big enough so that $a_{ij} = r_i + c_j$ then it is possible to increase some of the r's and c's and decrease others in such a way as to reduce the sum S. When S can no longer be reduced it will be possible to make a selection in at least one way so that S is the maximum score possible for an assignment.

In our case, we originally take all row numbers 0, and column numbers 7, 6, 7, 7, 7, 5, 7, 6, with $S = 52$ thus:

Positions (columns) / **Men** (rows)

Men	1	2	3	4	5	6	7	8	ri
1	1	5	4	7	7	3	6	6	0
2	4	2	5	4	6	1	2	5	0
3	6	5	2	4	4	2	5	3	0
4	7	1	7	3	2	5	5	4	0
5	3	6	7	3	2	5	5	4	0
6	7	5	6	7	6	1	4	6	0
7	6	1	5	2	2	1	7	3	0
8	4	4	7	3	2	1	3	1	0
cj	7	6	7	7	7	5	7	6	

We find there are no top scores in the second or third row and so a selection from these top scores is not possible. Having failed in our first attempt, let us reduce all column numbers by 1 and replace the row numbers by 1, 0, 0, 1, 1, 1, 1, 1. We have decreased our column total by 8. S is now reduced to 50 and the condition $r_i + c_j \geq a_{ij}$ still holds in all cases. Let us circle the top scores for this choice:

Positions (columns) / **Men** (rows)

Men	1	2	3	4	5	6	7	8	
1	1	5	4	7	7	3	6	6	1
2	4	2	5	4	6	1	2	5	0
3	6	5	2	4	4	2	5	3	0
4	7	1	7	3	3	2	1	5	1
5	3	6	7	3	2	5	5	4	1
6	7	5	6	7	6	1	4	6	1
7	6	1	5	2	2	1	7	3	1
8	4	4	7	3	2	1	3	1	1
	6	5	6	6	6	4	6	5	

The optimal assignments

We can now find an assignment from these top scores. There are in fact three different ways of doing this:

Men	1	2	3	4	5	6	7	8
Position Assignment	4	5	2	1	6	8	7	3
	8	5	2	1	6	4	7	3
	5	8	2	1	6	4	7	3

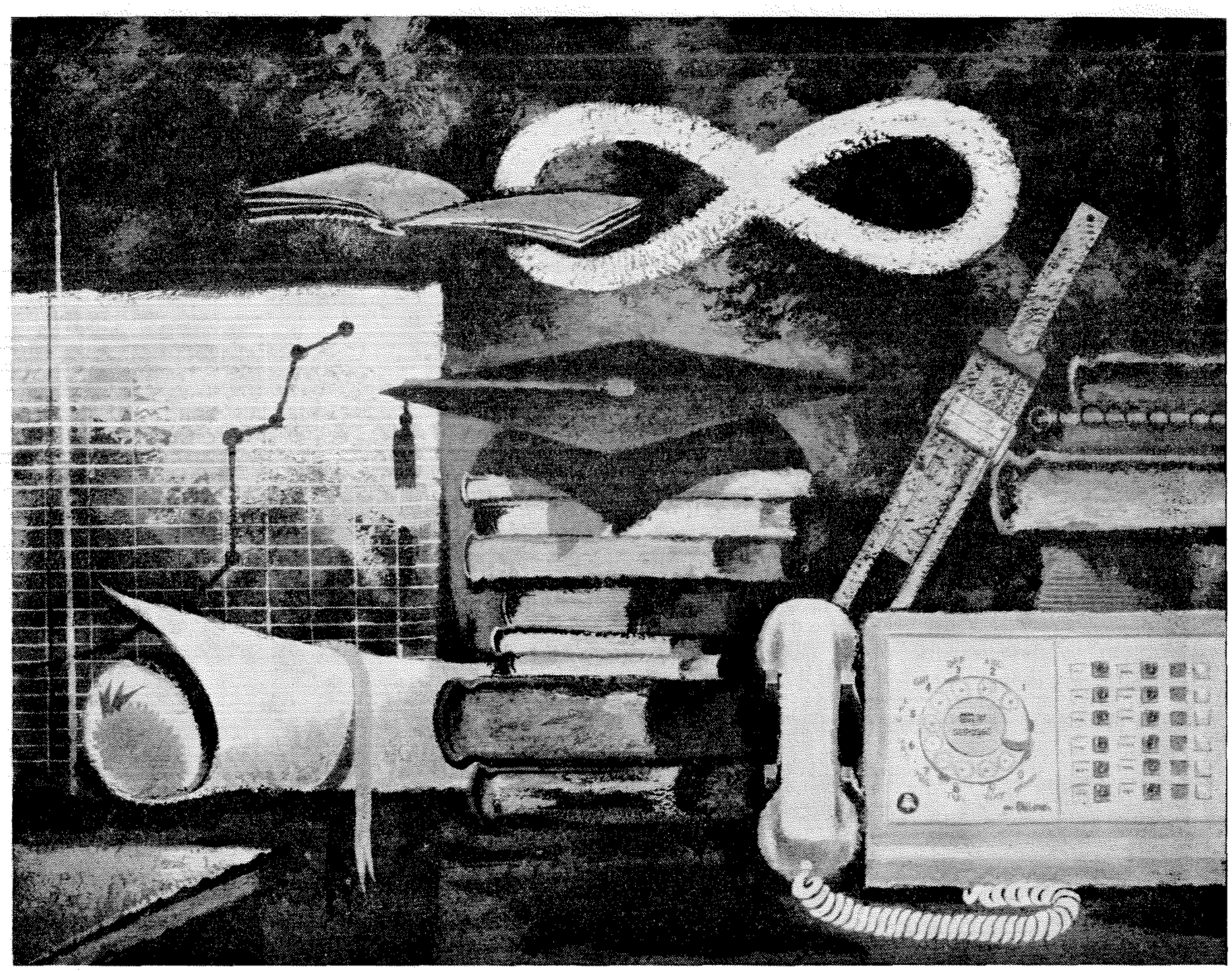
Assignment score S = 50.

Notice that in all three assignments we must place the third man in the second position, even though this is not the best score possible for the man or the best score possible for the position.

A set of rules is known so that whenever a particular set of row and column numbers, such as our first choice, does not give an assignment from the top scores, then the row and column numbers can be altered to give a smaller value for S. This process can be continued until an assignment can be found from top scores giving us the value of S as the assignment score. In our example we reached this stage in our second choice of row and column numbers.

Algebra – holding its own

In summary, algebra is doing better than holding its own in modern technology. There seems to be no end to the sequence of new and difficult problems which keep arising, but successful solutions are numerous and encouraging for the future.



A NEW IMAGE

Every so often, some magazine decides to do a story on the 150+IQ pranksters at Caltech, dredging out and redescribing old and forgotten practical jokes of years past, and spewing generalities about how bright all we Techmen are. January must have been a favorable month for this sort of story this year, because two of them appeared.

One of the magazines joining the Let's-Push-Caltech crusade was *Los Angeles*, a local-consumption monthly combining nightclub floorshow listings with Southern California Boosterism. The other was one of those magazines for MEN, specializing in the "Ted Maldoror fought his way through the sharks, and swam toward the golden twilight of the sea's surface.

'Does Cecily still love me?' he thought as he carried upward the thousand-year-old gold of the Aztecs he saved from the deadly Indian Ocean" type of story, in addition to articles on such titillating topics as the sex life of poor old President Harding. What virtuous, unadventurous Techmen were doing in a magazine like *this* is unclear. But we were predictably described.

In fact, despite the disparate characters of the magazines containing them, both Caltech articles were remarkably the same. About the most notable difference was that one article glorified Techmens' lock-picking talents, and the other talked about card-stunt stunting. Big Difference. Essentially, both of them conveyed the trite old idea that Techmen are smart, overworked, and incredibly ingenious when it comes to stunts. Big Deal. People and magazines more highly thought of than either of these have been saying this sort of thing for years. Caltech's image seems set in the eyes of the world, disregarding most everything that's true. Pity.

Pity, because a lot of the old image *is* untrue, and also because it creates confusing consequences in the big old outside world. Let's talk about consequences now, and image changes later:

Consequence One: Magazine articles like these lead Techmen to meet the Wrong Kind of Girls. Since my name is mentioned in one of the articles, I am in receipt of the following letter from a Miss D. who claims to attend Texas Christian University:

> My Lance:
>
> My name is Linda D., freshman at T.C.U. at Fort Worth, Texas. I have jest finished reading an articel on you all about Cal Tech. Had to rite and find out what is realy goin on over there . . . Finialy found a school with a little sense of "humour". . . Mabe one of you could *push* a *bed* to T.C.U. for some public relations sometime.
>
> Love,
> Linda D.

The letter was accompanied by a picture of a rather moosey brunette playing a ukelele. This is the kind of girl for a 150+ IQ intellectual?

Consequence Two: Magazine articles like these make Techmen shy and bashful in the company of virile males from other colleges. If ever I see another article quoting Bert LaBrucherie, philosophizing as only a disappointed-football-coach-turned-philosopher can, about how Caltech football is good, clean, honest sport, and we only finish last because we work too hard studying—I am going to go out and croak. Even if we *are* such mediocre athletes (which is actually untrue; the swimming team, for instance, has whipped the conference three years in a row), why publicize it? It's embarrassing to show up at such football powerhouses as Azusa Bible College and Western Ozark Valley Teachers College, and be asked, "But ain't you the football team that lost 25 games in a *row*?" We is, buddy, but why rub it in?

Consequence Three: Techmen are always branded as pranksters. If the Harvard fellows think it's bad being Commsymps, they ought to be in *our* shoes. Walking into a typical bar, for example, is always a predictable adventure for a Techman.

You order a beer. Then you talk to the guy next to you, who turns out to peddle nuts and bolts for the Irving Kurtz Steel and Pig Iron Corporation. After discussing the bolt market at length, he asks you what you do, and you (with trepidation) reply that you go to Caltech.

"Ho, ho, ho," he says, rubbing his belly through his $47.95 double-breasted conservative green suit, "You fellows really pulled a clever stunt up there at the Rose Bowl, didn't you? But you know when I was back at North Dakota State, we did something even better. It went like this. . ."

And then you're in for it. An hour later and five beers poorer, you know all about how the fellows let the air out of old Dean Blowbottom's tires, and fed a chicken up with Rice-Krispies and put him in the back seat and waited for consequences. As I said before, Big Deal. The Kurtzian bolt-peddler might live in his memories of the Good Old Days, but that's no sign I have to.

Thus, the time has obviously come for a new Caltech image. Maybe a start comes from all those scientist-fellows that are always posing for cigarette ads. You know the picture—tall, slightly graying, Scotch-and-soda, middle-aged-hotrodder types who are always firing off rockets at the moon. Perhaps a suitable modification of one of these chaps could apply to Caltech.

Picture a serious young six-foot-two science student just strolling from his lab to be met by a dedicated young scientist's girl friend who looks like Piper Laurie. The Techman would have a square jaw, a deep suntan, and be smoking a briar pipe. His lab jacket would be Brooks, button-down. He would walk with an air of noble dignity.

Poses later in the day would show this brave young scientist giving Pancho Gonzales a good run in an impromptu tennis match, or driving his true love toward the city and the Cocoanut Grove in his XK-E, or seriously studying for ten minutes as the clock strikes two, before retiring with a glass of port and a good book in his tastefully but seductively furnished suite.

Now, this is the sort of image Caltech wants—cultivated urbanity instead of escapist collegiate pranks and whimsy. But can we get this kind of image? You bet your life we can't. *We* are the overworked, high-IQ, terribly dedicated pranksters, etc., of Caltech. Oh, for a trip to Princeton.

But, until the day of the great change—anybody wanna hear how we changed the cards at the Rose Bowl? Hee, hee, hee.

—*Lance Taylor '62*

Dedicating the new Firestone Laboratory — Leonard K. Firestone, president of the Firestone Tire & Rubber Company of California; President DuBridge; J. E. Trainer, executive vice president of Firestone; and Clark Millikan, director of Caltech's Graduate Aeronautical Laboratories.

The Month at Caltech

Firestone Laboratory

The Firestone Flight Sciences Laboratory, which provides the Institute with new facilities for studying problems in space technology, was dedicated on February 5.

The five-story structure, the latest addition to the building complex of Caltech's Graduate Aeronautical Laboratories, was made possible by a gift of $1,050,000 from the Firestone Tire & Rubber Company.

"It is particularly fitting that this building be dedicated for use in flight sciences," said Leonard K. Firestone, president of the Firestone Tire & Rubber Company of California, "because Caltech produces some 20 to 25 percent of all the PhD's in aeronautics in this country . . . Caltech graduates hold key positions in the research and manufacturing centers that have made southern California preeminent in aeronautics and space technology."

The new 30,000-square-foot laboratory will be used chiefly for studies of missiles and high speed aircraft structures, solid propellants for rockets, fatigue and cracking of metals, flutter and vibration of thin-walled structures, gas flows at very high speeds and temper-

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If it isn't fun, don't do it!
There are those who will tell you that the world beyond the academic walls is (a) highly competitive, (b) full of opportunity, and (c) above all, serious business. Although we are keenly aware of the serious implications of the advanced propulsion work we're doing, at UTC we take a somewhat different view.
We believe that the right man in the right job will *enjoy* what he's doing. He'll find the competition stimulating, the challenge exciting. He'll be eager to get to work in the morning, simply because his work is *fun*. And this enthusiasm is bound to rub off on the paycheck, make no mistake about that.
Now, while you're giving serious thought to your future, we invite you to check out the possibilities here at UTC. For more information, write Jay Waste, Dept. 113.
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atures, and advanced mathematical investigations in fluid and solid mechanics.

Leaders of America

The Rt. Rev. James Pike, J.S.D., S.T.D., Bishop of the Diocese of California of the Protestant Episcopal Church visits the Caltech campus from February 13-15 as the first guest in this year's Leaders of America program, sponsored by the Caltech YMCA.

The Leaders of America series is designed to bring outstanding individuals to visit with Caltech students on an informal basis. During his stay on campus, the guest meets with students in classes, group discussions, and public meetings. He lives on campus and eats in the student houses.

Bishop Pike is a graduate of the University of Southern California, where he received his LLB in 1936. He was admitted to the bar of the State of California in 1936 and practiced law until 1942, when he made the decision to become a student of theology at the Virginia Theological Seminary. In 1944 he was ordained deacon of the Protestant Episcopal Church, and served as curate of St. John's Church in Washington, D.C. He was Episcopal Chaplain at Vassar College from 1947 to 1949, and from 1949 to 1952 was head of the department and professor of religion at Columbia University. From 1952 to 1958 Bishop Pike was Dean of the Cathedral of St. John the Divine in New York City, and in 1958 he became Bishop of the Diocese of California.

Bishop Pike is the author of *A Roman Catholic in the White House*, *If You Marry Outside of Your Faith*, and *The Church, Politics and Society*.

The second visitor in the Leaders of America program will be Sydney Hook, chairman of the graduate division of philosophy at New York University, who will be on campus from April 11-13.

Faculty Changes

Robert C. Jahn, assistant professor of jet propulsion, has resigned from Caltech to be assistant professor of aeronautical engineering at the Forrestal Research Center at Princeton University.

Maurice Levy, professor of theoretical physics at the University of Paris, and director of the Laboratory of Theoretical and High Energy Physics at Orsay, France, is at Caltech for a year as visiting professor of theoretical physics.

Charles R. McKinney, senior research fellow in geology, has left the Institute to become a senior engineer at the Consolidated Electrodynamics Corporation in Pasadena.

Ray C. Owen, who has been serving as acting chairman, has been appointed chairman of the biology division of the Institute.

Honors and Awards

Ian Campbell, chief of the California Division of Mines and Geology, and research associate of the division of geological sciences at Caltech, will receive the Hal Williams Hardinge Award of the American Institute of Mining, Metallurgical, and Petroleum Engineers on February 20 at the Institute's 91st an-

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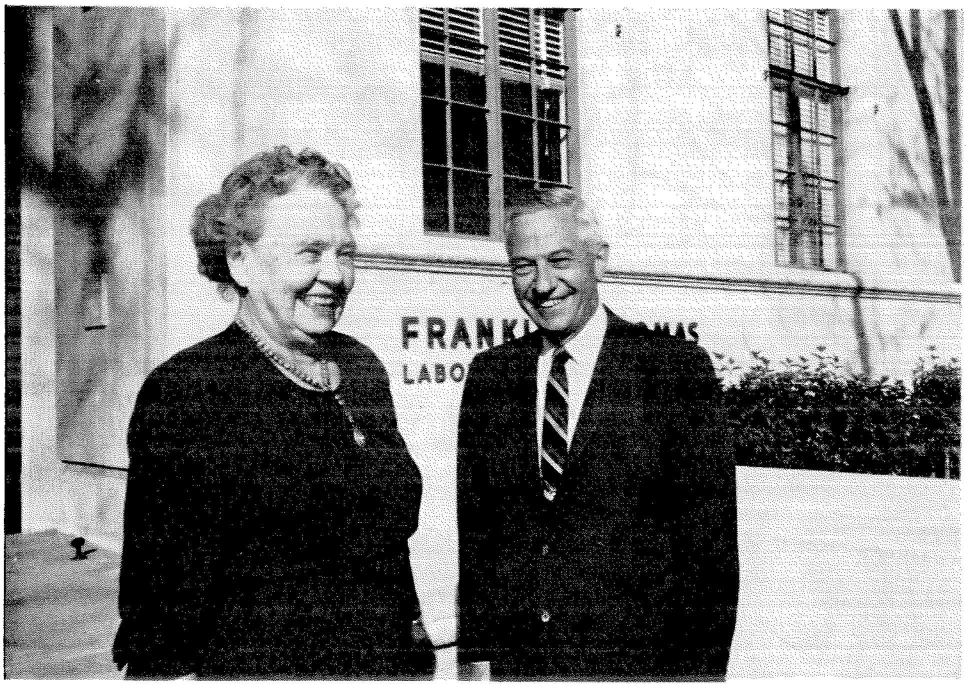
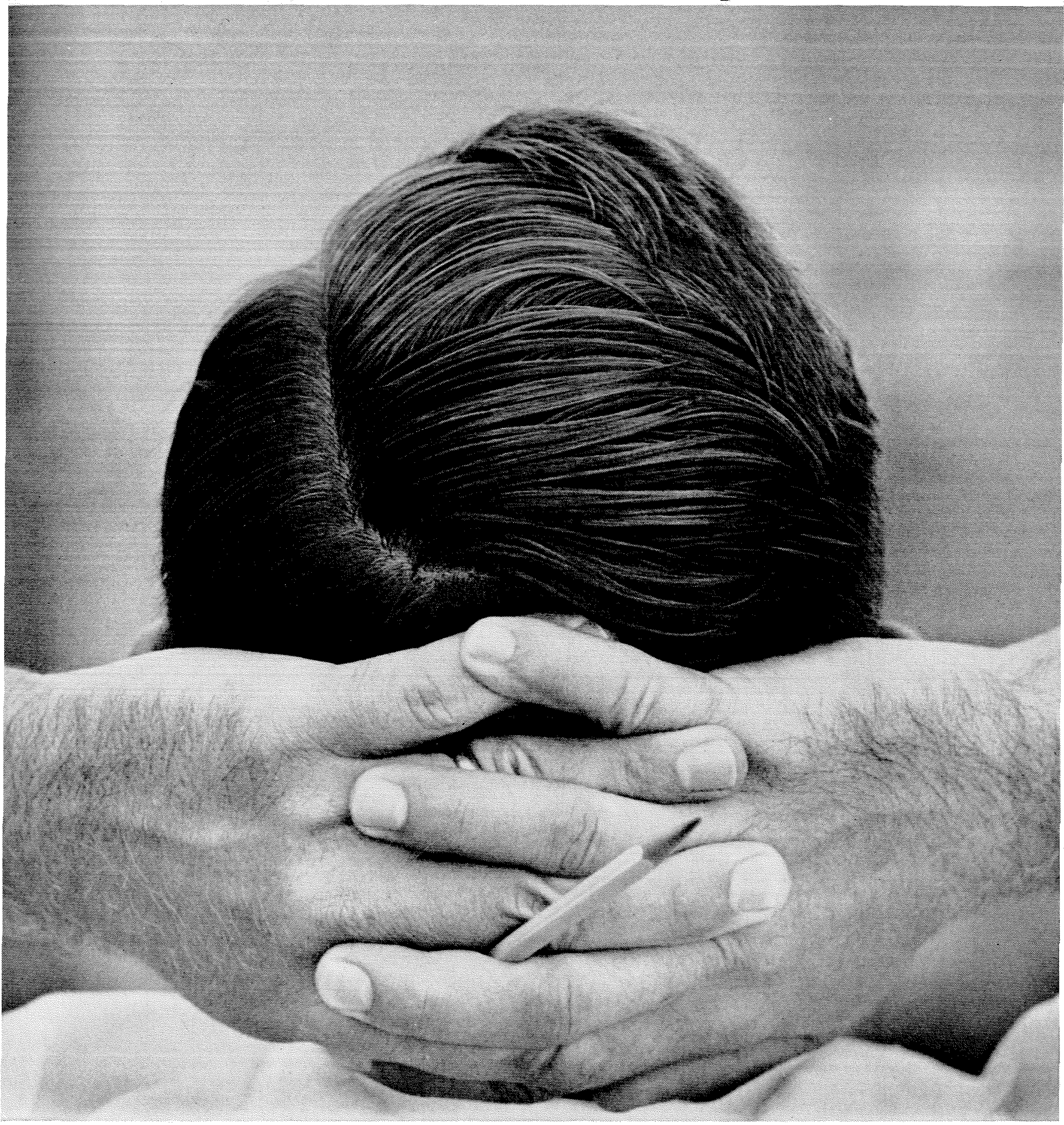


THOMAS LABORATORY

Mrs. Franklin Thomas and President DuBridge give official recognition to the newly-designated Franklin Thomas Laboratory of Engineering. The five-story engineering building, constructed during and just after World War II, has been renamed in honor of the late Dean Thomas, authority on water supply, Pasadena civic leader, and professor of civil engineering at Caltech for 39 years.

How many of his dreams do you share?



This man gets paid for dreaming. He seeks out new questions to ask, new goals to aim at. His insights shape the course of tomorrow's technology.

Are you ready to put aside easy answers and help establish new parameters of knowledge? Then come to Northrop. Work in such uncluttered areas as space guidance and astro-inertial navigation systems, aerospace deceleration and landing systems, man-machine and life-support systems for space, laminar flow control techniques, automatic test equipment or world-wide communications systems. With more than 70 such advanced projects on the boards, you'll find all the creative challenge you could ask for.

nual meeting in New York. The award goes to Dr. Campbell as: "Eminent scientist, author, educator, and administrator; for his personal warmth, outstanding leadership, and devoted service to the profession." Dr. Campbell was a member of the Caltech faculty from 1931 to 1959.

Cushing Strout, associate professor of history, has been appointed Whiton Visiting Professor for 1962-3 at Cornell University in Ithaca, N.Y.

Fritz Zwicky, professor of astrophysics, has been elected a member of the new International Academy of Astronautics. Theodore von Karman, Caltech professor of aeronautics, emeritus, is director of the academy.

Michael T. Wermel

Michael T. Wermel, research associate in economics and insurance in Caltech's Industrial Relations Center since 1955, died of a heart attack on February 6 in Hawaii. He had been on a leave of absence from the Institute since 1960 to serve as professor of economics and dean of the school of business of the University of Hawaii in Honolulu.

A graduate of New York University in 1931, Dr. Wermel received his PhD from Columbia University in 1939. He was with the Inter-Allied Control Council of the military government in Germany in 1946-7, and had taught at Brooklyn College, American University in Washington, D.C., Tufts University in Medford, Mass., and the University of California at Berkeley. Dr. Wermel is survived by his wife and two daughters.

Lecture Series

Two Caltech scientists will be featured speakers in the Los Angeles County Museum's Second Annual Science Lecture Series: Richard P. Feynman, Richard Chace Tolman Professor of Theoretical Physics, who will speak on "The Law of Gravitation" on March 28; and Allan R. Sandage, staff member of the Mount Wilson and Palomar Observatories, on "Age and Evolution of the Universe" on April 18. The series gets under way on February 21 when Harold Urey of the University of California at La Jolla speaks on "The Origin of the Solar System," and concludes with a talk by Gordon Macdonald of UCLA on "Tides, Time, and Ptolemy" on May 16.

Enrolled at Dynamic TULANE

MEN'S DORMITORY. Main Architects: *Diboll-Kessels and Richard Koch; S. Wilson, Jr. & Associates.* General Contractor: *Farnsworth & Chambers.* Mechanical Contractor: *Cabirac Mechanical Contractors, Inc.* Consulting Engineers: *Jos. E. Leininger & Associates.*

APARTMENT BUILDING *for married students.* Main Architects: *Goldstein, Parham & Labouisse.* General Contractor: *J. A. Jones Construction Co.* Mechanical Contractor: *Sciambra & Masino.* Plumbing Contractor: *Jas. F. O'Neil Co., Inc.* Consulting Engineers: *Design Engineers & Associates.*

JENKINS VALVES

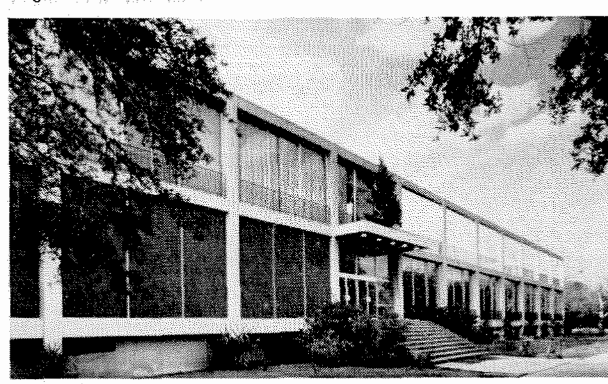
for long-range dependability, long-time maintenance economy

"Dynamic" is the word for tradition-laden, prestige-rich, 127-year-old Tulane University in New Orleans.

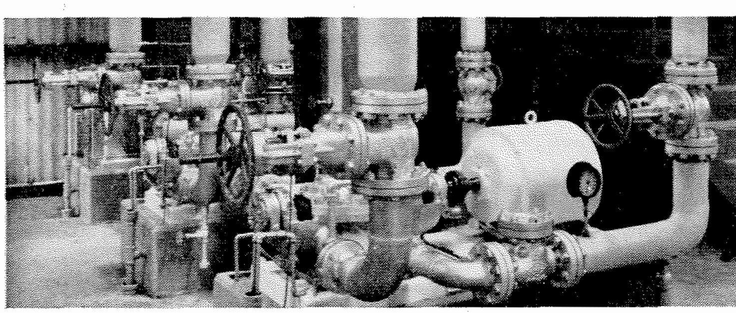
Nowhere is Tulane's dynamism more remarkable and articulate than in its current building program.* Examples: the three brand new, beautiful and beautifully functional structures pictured here.

If you toured these buildings and the power plant which serves the campus complex, again and again and again you'd see the distinctive Diamond-mark that identifies Jenkins Valves. And small wonder: a university which had its beginnings more than a century ago just naturally thinks in terms of long-range dependability, long-time maintenance economy . . . precisely the qualities which make Jenkins Valves the "Standard of Quality" by which other valves are measured! Yet — and this fact still comes as a pleasant surprise to some specifiers — *they cost no more!* Jenkins Bros., 100 Park Ave., New York 17.

*Tulane's supervisory and liaison personnel for the building program: Harold E. Pique, Director of Planning; George F. Johnson, Director of Physical Plant; Charles E. Gilbert, Utilities Superintendent.



UNIVERSITY CENTER *features swimming pool, bowling lanes, radio station, cafeteria, ballroom.* Main Architects: *Curtis & Davis and Associates; Edward Silverstein.* General Contractor: *Farnsworth & Chambers.* Mechanical Contractor: *Sciambra & Masino.* Consulting Engineers: *Leo S. Weil; Walter B. Moses.*



POWER PLANT. *Boiler feed water pumps and Jenkins Valves shown.* Main Architects: *Paul Charbonnet, Jr.* General Contractor: *Gervais Favrot Co.* Mechanical & Plumbing Contractor: *Comfortaire Co., Inc.* Consulting Engineers: *Leo S. Weil; Walter B. Moses.*

JENKINS

MOST TRUSTED TRADEMARK IN THE VALVE WORLD

VALVES

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Jenkins Bros

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Personals

1928

Frank Noel is a designer in the Douglas Aircraft Company's space mechanical support engineering section at Vandenberg Air Force Base. He and his wife recently returned from a five-month camping tour, via Volkswagen bus, to the eastern states and provinces—as far as Sydney, Nova Scotia.

1929

L. Reed Brantley, MS, PhD '30, professor of chemistry at Occidental College, has been teaching there since 1930. He has also been a consultant in business and government and has done extensive research on the principles of adhesion.

1933

L. Eugene Root, MS, ME, MS '34, AE, president of the Lockheed Missiles and Space Company, has been elected 1962 president of the Institute of the Aerospace Sciences. He is group vice president of Lockheed Aircraft Corp. for missiles and electronics—a job that entails direction of the Missiles and Space Division, Lockheed Electronics Co., and the Grand Central Rocket Company.

1934

Carsten Steffens, PhD, senior scientist and research coordinator of the Stanford Research Institute in Menlo Park, left in December for Tokyo to become director of a new branch office in Japan. SRI now has representatives in Japan, Switzerland, Italy, England and Ontario, Canada.

1937

Claude B. Nolte is now president of L. J. Cannon Manufacturing Co., Inc. in Placentia. He was formerly an engineering and management consultant to the company, which manufactures recording pens for the instrument industry.

1938

Donald L. Putt, MS, president of the Institute of Aeronautical Services and United Technical Corporation in Menlo Park, has been appointed chairman of the Visiting Committee to the department of mathematics at the Carnegie Institute of Technology in Pittsburgh.

1939

Kenneth G. Macleish has been elected a vice president of the Perkin-Elmer Corporation in Norwalk, Conn., and has also been named director of the firm's electro-optical division. Ken had been assistant director of research and engineering in the apparatus and optical division of the Eastman Kodak Company, where he worked for 18 years.

1940

William C. House, director of NERVA (nuclear engine for rocket vehicle application) operations of the Aerojet-General Corporation, has been named a vice president of the company. He has been with Aerojet since 1949. Four months ago he received the Navy's Meritorious Public Service Citation for his work on the Polaris missile.

Randlow Smith, MS '41, chief design engineer in Texaco, Inc.'s, engineering department in Houston, Texas, is co-recipient of a new patent covering improvements in "sulfuric acid alkylation

continued on page 38

with effluent refrigeration and depropanizer bottoms flashing."

1941

Joseph W. Lewis, manager of the scientific and process instruments division of Beckman Instruments, Inc., in Fullerton, has been named a vice president of the company. He will serve as a member of the Corporate Planning Committee in addition to his responsibilities as division manager. Joe is the current chairman of the Caltech Alumni Fund Council. In 1948 he was president of the Caltech Alumni Association. The Lewises, who live in San Marino, have three children.

Lawrence C. Widdoes, PhD '61, president of the Internuclear Company in University City, Mo., is now director of research at the Petrolite Corporation in Webster Groves, Mo.

Joseph P. LaSalle, associate director of the Center for Differential Equations at the Research Institute for Advanced Study in Ruxton, Md., is president-elect of the Society for Industrial and Applied Mathematics. He will take office in the fall.

1942

Charles W. Seekins, PhD, chairman of the mathematics department of Occidental College, has been appointed chairman of the Natural Sciences and Mathematics Division for a period of three years.

Wolfgang K. H. Panofsky, PhD, is now director of the $114 million, two-mile-long linear accelerator, financed by the U.S. Atomic Energy Commission, which is under construction at Stanford University. The new accelerator is expected to take about six years to complete after ground is broken next spring, and will employ about 700 persons. Dr. Panofsky has been on the Stanford faculty since 1951.

John R. Allan is now chief engineer of the Los Angeles Division of Todd Shipyards Corporation. He has been with the company since his graduation. The Allans live in Lomita and have two sons: Robert, 13, and Richard, 9.

Peter L. Nichols, Jr., PhD, is now senior scientist at the solid rocket plant at Aerojet-General Corporation in Sacramento. He was formerly director of the space sciences and propulsion division of the Stanford Research Institute. He is also consultant to the office of the Assistant Secretary of Defense for Research and Engineering; a member of the Joint Army-Navy-Air Force Panel on Propellant Performance; and on the Department of Defense Panel on Combustion Instability.

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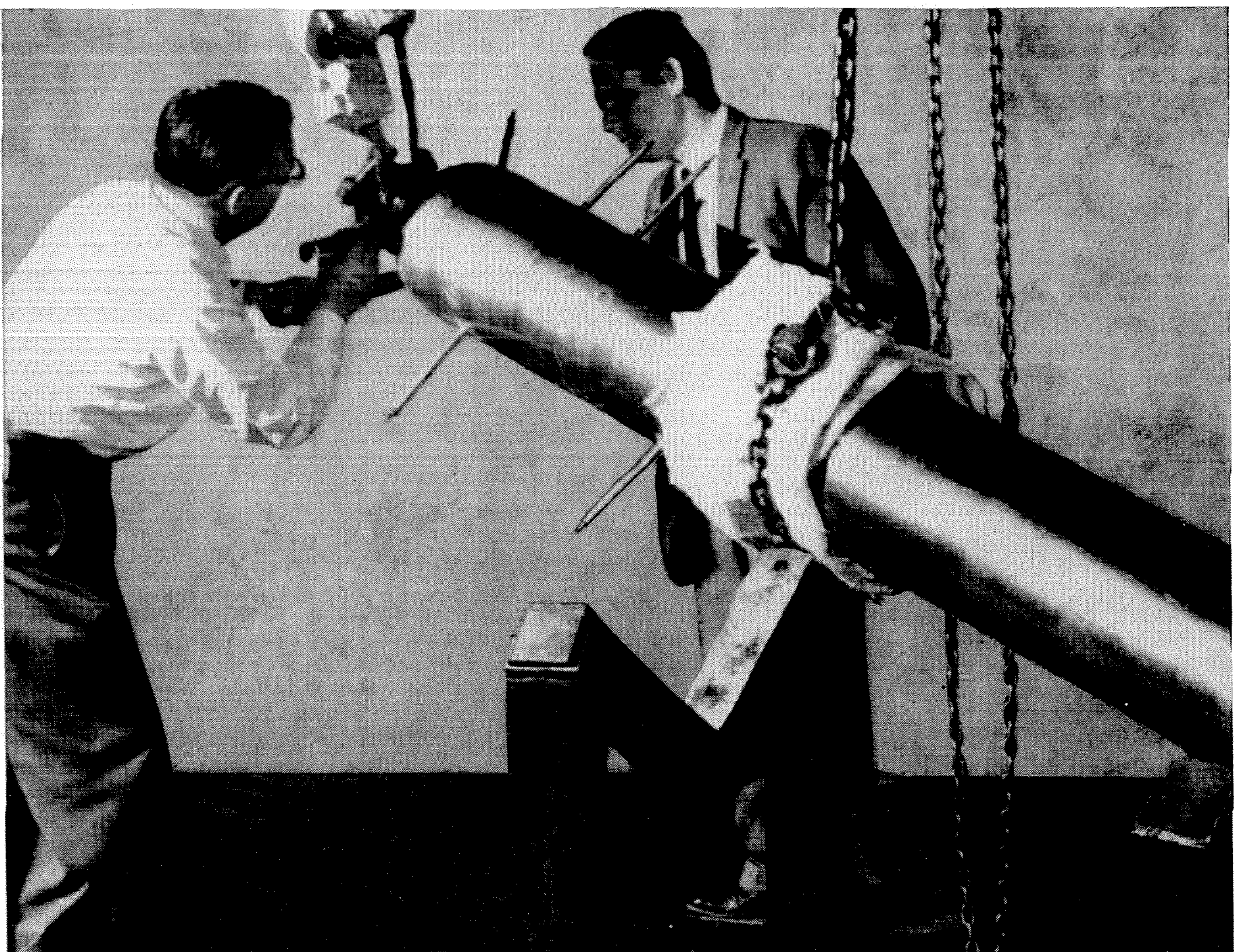


Grinnell and Westinghouse engineers hydrostatically test piping for Westinghouse nuclear reactors

Grinnell prefabricated pressure vessels maintain environmental conditions in Westinghouse test loops

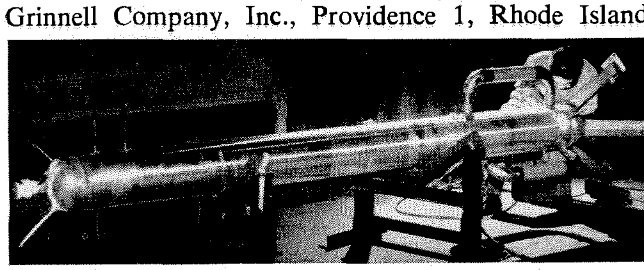
This torpedo-shaped vessel, which is made of centrifugally cast stainless steel pipe, will play a vital role during nuclear research reactor experiments at Westinghouse. Its job — maintaining the desired pressure in a high temperature, high pressure in-pile test loop.

These in-pile loops required the exacting fabrication skills and equipment available in Grinnell's extensive shop facilities. Shop test equipment and procedures assured conformance to tolerances several times more critical than normally necessary.

Grinnell assumed sole responsibility for safe delivery of finished components. Specifications included accurate machining, argon shielded welding, selection of welding rod and flux materials for smooth interior weld surfaces, step-by-step inspection — even complete radiography of centrifugally cast stainless steel pipe.

Whatever your field, you'll find Grinnell shop-fabrication greatly reduces costs of cutting, fitting, welding, assembling and final erection. You are assured of adequate facilities for producing pieces of any size, at costs known *before* you start. What's more, you get the advantages of *one-company responsibility.*

Consult Grinnell on your next piping installation. Grinnell Company, Inc., Providence 1, Rhode Island.



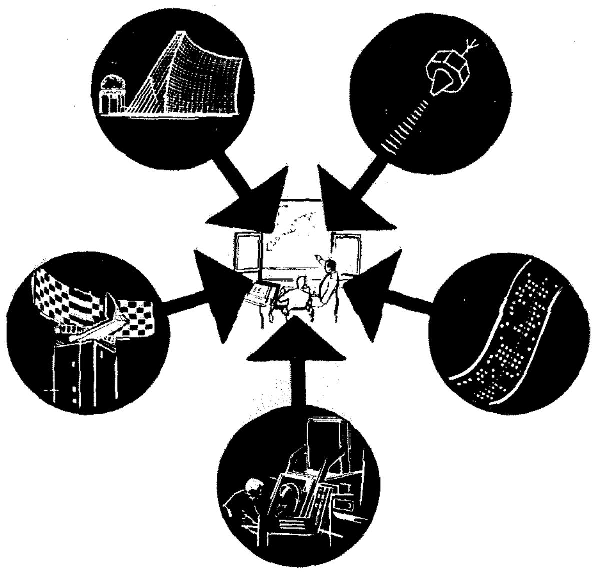
Grinnell shop-fabrication assures conformance to tolerances several times more critical than normally necessary.

GRINNELL

Pipe Fittings, Prefabricated Piping, Piping Specialties and Engineered Pipe Hangers

Branch Warehouses from Coast to Coast

ENGINEERING GRADUATES HAVE FOUND ATTRACTIVE OPPORTUNITIES WITH GRINNELL



Personals . . . *continued*

1943

Leon Katz, PhD, professor of physics at the University of Saskatchewan in Saskatoon, Canada, has been appointed director of a new accelerator laboratory. He is responsible for the installation and operation of the $750,000 accelerator which will be housed in a building the university will erect at a cost of $400,000 to $600,000. The new unit is expected to be functioning by 1963.

Hewson Lawrence, MS, is now manager of Aerojet's Customer Relations District Offices. He moves into the new position after serving as Director of Division Customer Relations since 1959, and before that, he worked for 13 years with Aerojet in Azusa and Washington.

1944

Ruben F. Mettler, MS '47, PhD '49, has been elected a Fellow of the Institute of Radio Engineers, the highest membership grade in the Institute. Rube is executive vice president of Space Technology Laboratories, Inc., a subsidiary of Thompson Ramo Wooldridge, Inc., in Canoga Park.

Gregory Young, MS '47, associate professor of electrical engineering at the University of Southern California, is now doing research in computer decision processes to develop methods for the solution of mathematical problems which no man could work in a lifetime. Greg has been on the USC School of Engineering faculty since 1956.

1945

John L. Leech is now director of product sales for Monsanto Chemical Company's inorganic chemicals division in St. Louis. He was formerly manager of surfactant sales.

1946

Cdr. Kenan C. Childers, Jr., MS, AE, commanding officer of the Naval Aeronautics Space and Missile Center at Point Mugu, recently received the Legion of Merit for his efforts in connection with the Navy's missile program.

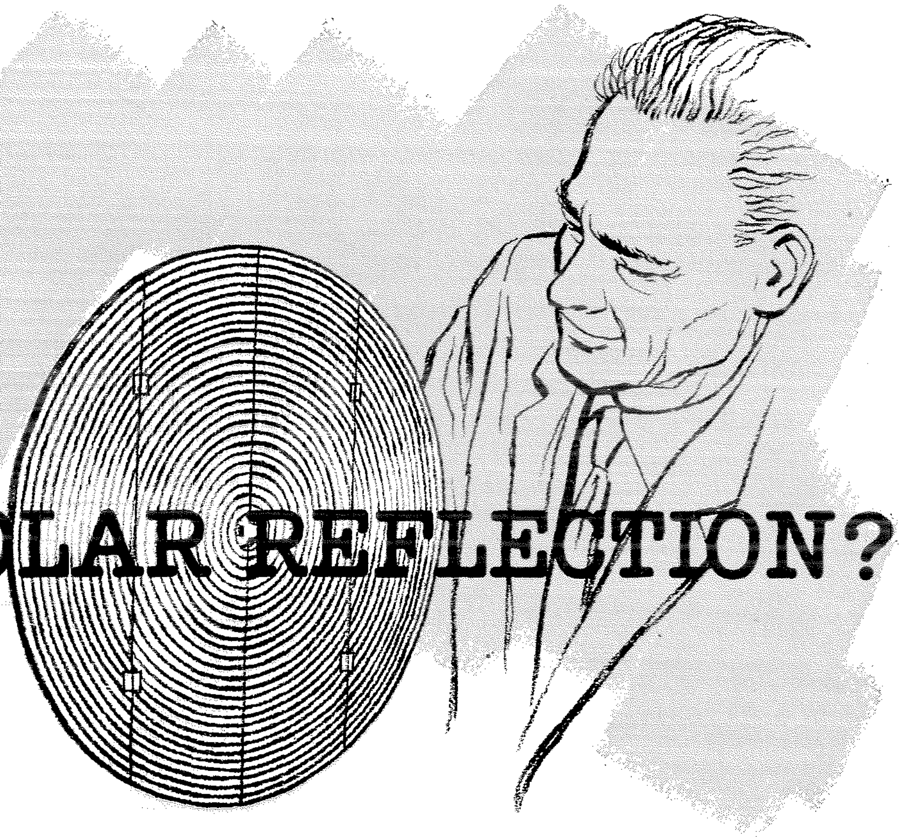
1947

Cdr. Edward G. Bull, AE, retired from the Navy last August and is now manager in charge of research manufacturing at the Hamilton Standard Division of the United Aircraft Corporation in Windsor Locks, Conn.

1950

Joseph H. Birman, MS, associate professor of geology at Occidental College in Los Angeles, has been at Occidental since 1949. He is an authority on glacial geology, and works as a geological consultant to business firms.

Take a new direction in SOLAR REFLECTION?



● That's just what we did at Allison.

Studies indicated that the Fresnel principle could be adapted to an extremely lightweight, foldable solar collector for operation of power systems.

Our researchers went to work, aided by Allison's extensive resources—our physical optics and metallurgical laboratories, American and European consultants, our Scientific Advisory Board and every resource General Motors possesses.

Results—a Fresnel mirror which can collect and concentrate solar energy to run direct conversion systems, Stirling cycle engines, Rankine cycle mercury turbines, solar regenerated fuel cells and numerous other devices which will provide electric power for space missions.

Allison's solar reflector utilizes such significant design characteristics as:

70% less weight than other solar reflectors capable of withstanding the rigors of space for extended periods of time . . .

Strong enough to withstand the severe stresses encountered in rocket blast-off and boost . . .

Can be folded to fit a rocket case during launch, automatically unfolded once orbit is attained . . .

And this is but one example of Allison technology at work. Current research investigations encompass four basic energy conversion systems: open and closed cycle gas turbines, Stirling-cycle engines, direct energy conversion devices and rockets. From this research into solar and nuclear as well as chemical energy will develop many of the primary and auxiliary power systems of the future.

But concepts are constantly changing, and Allison is ever probing new forms of energy conversion in the search for improved forms of propulsion and power. And as the research devices of today become the power systems of the future, Allison will continue its history of pioneering and progress in power.

Energy Conversion is Our Business

ALLISON DIVISION GENERAL MOTORS CORPORATION

CIRCLE THIS DATE ON YOUR CALENDAR

Saturday—24 March 1962

ANNUAL ALUMNI DINNER DANCE

at the

Golden State Room, Statler Hilton Hotel

LOS ANGELES

Cocktails at 6:30—Dinner at 7:30—Dancing at 9

ALUMNI FUND REPORT . . .

Where we are —
Where we're going.

Let us begin with the good news.

Through the 31st of December, gifts to the Alumni Fund for endowment total $32,721.03. Included is $1,405 from corporate gift matching programs.

Restricted for purposes other than endowment, but still credited to the Alumni Fund is $13,602.84. This sum includes contributions to the Gnome Club Scholarship and General Scholarship Funds and restricted gifts to various Institute operations such as Engineering, Geology, and others.

The total sum credited to the 1961-62 Alumni Fund, then, is $46,323.87 or 92.6% of our $50,000 goal.

In addition to these contributions, more than $37,000 has been received from alumni for trusts and a gift of equipment valued at $12,000.

We take this opportunity to thank you once again for your generosity. Tangible evidence of your interest in the Institute is both welcome and appreciated.

Now for the less heartening news.

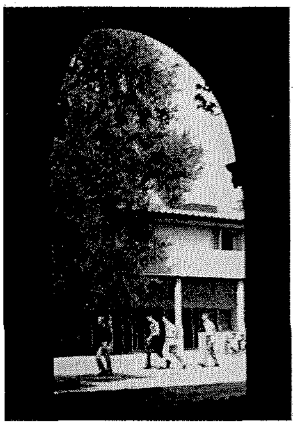
Donors to the Alumni Fund number only 1,073 or 13.7% of the alumni solicited. Put it another way; only one alumnus in seven has given. By any standard, this is not a good showing.

Between now and the end of June this year we hope to *triple* the present number of donors to a total of at least 3300.

As your Alumni Fund Director, *I* urge you to give, I am sure that the 1,073 *alumni donors* urge you to give and, as added emphasis, *George Sternmeyer* urges you to give.

So go ahead . . . give.

—Claude B. Nolte '37
Director, Alumni Fund



CALTECH CALENDAR

ALUMNI EVENTS

March 24	Annual Dinner Dance
May 19	Annual Alumni Seminar
June 6	Annual Aumni Meeting

ATHLETIC SCHEDULE

Tennis

February 20
Pasadena College at Caltech
February 24
Redlands at Redlands
February 28
Pomona at Caltech
March 7
Claremont-H. Mudd at Caltech

Basketball

February 20
La Verne at Caltech
February 23
Claremont-H. Mudd at Caltech

Swimming

February 23
Santa Monica CC at Caltech
February 24
UCLA & LA State at Caltech

FRIDAY EVENING DEMONSTRATION LECTURES

Lecture Hall, 201 Bridge, 7:30 p.m.

February 23
The Luxury of Culture
—Oscar Mandel

March 2
Radioactive Isotopes and Their Use in Immunochemistry
—Justine S. Garvey

March 9
A Look at New Alloys with the Electron Microscope
—Ronald H. Willens

March 16
Geochemical Role of Micro-organisms
—Isaac R. Kaplan

CALTECH VARSITY GAME SCORES

Basketball

January 5	Upland College	54	Caltech	49
January 6	UC Riverside	72	Caltech	69
January 9	Pomona	65	Caltech	55
January 13	Whittier	80	Caltech	52
January 16	Biola	60	Caltech	67
January 19	Claremont-H. Mudd	83	Caltech	56
January 23	Azusa College	62	Caltech	78
January 27	Redlands	62	Caltech	51
January 30	Occidental	74	Caltech	58

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Holley B. Dickinson, '36

VICE-PRESIDENT
William L. Holladay, '24

SECRETARY
Donald S. Clark, '29

TREASURER
John R. Fee, '51

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Menlo Park

The location of the informal weekly alumni luncheon, which is held on Thursdays at 11:45, has been changed to the 13th floor of the Engineers Club, 206 Sansome Street, San Francisco; Mr. H. Farrar, EX 9-5277, can be contacted for reservations on Thursday mornings.

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Division of Highways, State of California

Vice-President — G. Donald Meixner, Jr., '46
Dept. of Water Resources, State of California

Secretary-Treasurer — John Ritter, '35
Division of Highways, State of California

Meetings: University Club, 1319 "K" Street
Luncheon first Friday of each month
Visiting alumni cordially invited—no reservation

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3040 Udal Street

Secretary — Frank J. Dore, '45
Astronautics Div., Convair

Program Chairman — Herman S. Englander, '39
U. S. Navy Electronics Laboratory

Kodak beyond the snapshot...

(random notes)

Grateful but cautious

More spectrographic plates and film are used each year than the year before. This goes on despite new fashions in elemental analysis by physical methods and by new Eastman Organic Chemicals. The civilized world is analysis-happy and that makes *us* happy.

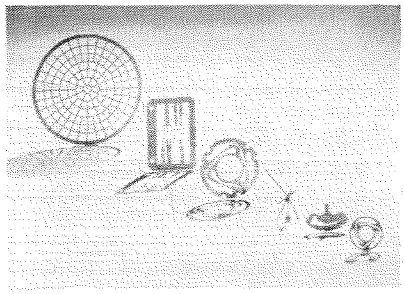
To betoken the happiness a small pamphlet has been issued under the title "Spectrum Analysis with Kodak Materials." Its words may prove less useful than its graphs and numbers, though the words devoted to a warning against taking the graphs and numbers too seriously must be taken seriously. That's life.

Life lived with the photographic emulsion as a measuring instrument for radiation intensity must be filled with gratitude for its simplicity, versatility, and economy and filled with caution against glib assumptions. Those who live that life have learned that:

1. *Kodak Spectroscopic Plates and Film, Type 103-0* work fast, capture quick-vanishing spectra.
2. *Kodak Spectrum Analysis No. 1 Plates and Film* are contrasty and good for trace-element lines against heavy background, for semi-quantitative comparison, and for all-out quantitative jobs.
3. For cutting corners on how many wave lengths you calibrate at, resort to the new *Kodak "SA-3" Plates or Films.*

(If you still want the pamphlet, write to our Special Sensitized Products Division.)

Never say "die"?



These metal parts are not stampings. They are too fussy and tricky for knife or milling machine and needed too fast and in insufficient numbers to justify the fabrication of dies. They are products of photo-etching, which is catching on.

Some outfits photo-etch for themselves, and some do it for hire. The method uses either *Kodak Photo Resist* or *Kodak Metal-Etch Resist,* depending on the metal. Both are light-sensitive liquids. The object is drawn to enlarged scale and photographed. The metal is coated with *KPR* or *KMER* and exposed to light through the negative. Where the negative protects from the light, the resist will subsequently flush away; where light-struck, it becomes resistant to etchant. Etchants leave no burrs. The thinner the metal the closer the tolerances an etchant can work to.

Photo-etching speeds execution of design ideas. With fewer punch-press tenders needed nowadays anyway, more of the population has to earn a living in the idea business.

Chemical tuning

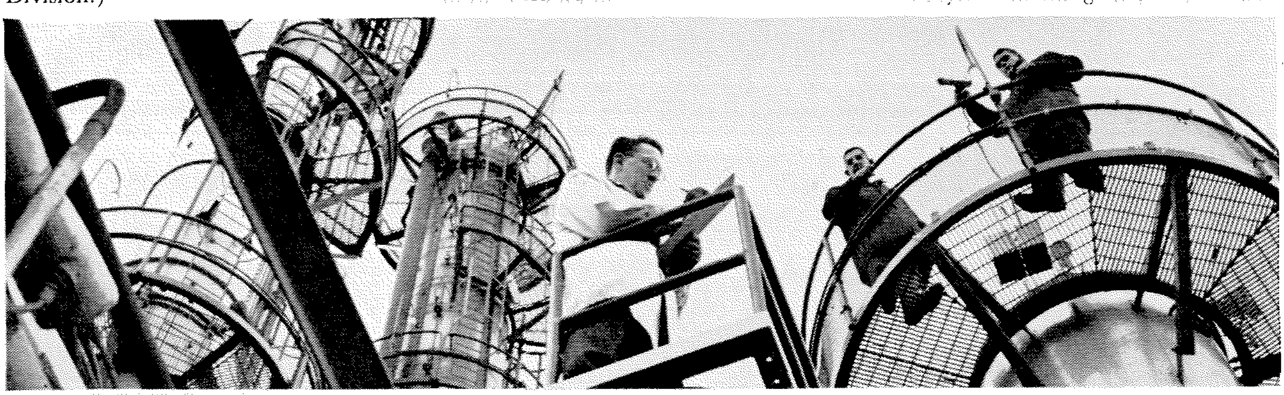
We make optical interference filters on a custom basis. In seeking customers one must be creative. Why not advertise them to chemists?

To a chemist, a color filter is what he slips into a colorimeter. If he is an enthusiastic photographer, he may know of dyed-gelatin Kodak Wratten Light Filters. We take it from there:

"Suppose, for fantasy's sake, that you wanted to flood a reaction *preferentially* with energy of exactly that frequency to which a certain carbon-nitrogen bond responds. An interference filter could probably be made for the job.

"An interference filter is tunable in manufacture for wavelengths from 0.4μ to 12μ. Unlike gelatin or glass filters, its curve doesn't depend on what colorants happen to be available. It can provide a single spectral spike of transmittance but is not limited to that. It can also be designed to cut out energy below a stated frequency or above a stated frequency. It can cut very sharp. It is thermally, chemically, and mechanically rugged. It costs a great deal less than a laser (which, while it can emit Niagaras of monochromatic energy, must work with the quantum states that Nature has in stock). It can be large. It can be designed to monitor a process stream continuously for the presence or absence of any substance possessing a suitable energy-absorbance curve."

Maybe something clicks somewhere.



INCREASING EXPLOITATION OF PHOTOCHEMICAL REACTIONS DEMANDS GOOD CHEMICAL ENGINEERS, AMONG OTHERS

From portrait lenses to polishing waxes, plenty of lively careers are to be made with Kodak in research, engineering, production, marketing.

And whether you work for us or not, photography in some form will probably have a part in your work as years go on. Always feel free to ask for Kodak literature or help on anything photographic.

EASTMAN KODAK COMPANY
Rochester 4, N.Y.

Kodak
TRADEMARK

One of a series

Interview with General Electric's
Francis J. Boucher
Manager-Manufacturing Personnel Development Service

How Good Is Your Best Job Offer . . .

Q. Mr. Boucher, with all the job interviews a graduating engineer goes through, how can he be reasonably sure he has made the right choice?

A. This is a good question because few seniors have enough work experience in industry, government and educational institutions to allow them to make a fully reasoned choice. However, I think the first step is to be sure that short-term factors like starting salary and location don't outweigh long-range factors like opportunity and professional growth. All of these factors should be evaluated *before making a final commitment.*

Q. But you do feel that starting salary is important?

A. Very much so. If you are married—it may be an even greater consideration. But you should also look beyond starting salary. Find out, for example, if the company you are considering has a good salary administration plan. If there is no way of *formally* appraising your performance and determining your appropriate rewards, you run the risk of becoming dissatisfied or stalemated due to neglect of these important considerations.

Q. What considerations do you feel should be evaluated in reaching a job decision?

A. Let me refer you to a paper written by Dr. L. E. Saline, now Manager of Information Systems in our Defense Systems Department. It is titled "How to Evaluate Job Offers." (Incidentally, you may obtain a copy by writing as directed in the last paragraph.) In it, Dr. Saline proposes six questions—the answers to which should give you much of the information you'll need for an objective job-offer evaluation. He suggests you determine . . .

- to what degree will the work be challenging and satisfying?
- what opportunities are available to further develop abilities?
- what opportunities are there for advancing in the Company (and how dynamic the Company is in the marketplace is an important
- what salary potentials are possible with respect to the future?
- what about geographical location—now and in the future?
- what effort does the Company make to establish and maintain a professional climate?

There is more to these questions than meets the eye and I think you would enjoy reading Dr. Saline's paper.

Q. What about the openings on defense projects that are listed in the various magazines and newspapers?

A. Presumably, there will always be a need for technical manpower in the defense business. But I want to point out to you that most of these opportunities are for experienced personnel, or personnel with specific additional training received at the graduate level.

Q. How do you feel about training programs? Do they offer any particular advantages over any other offer I might accept?

A. I feel training programs are particularly helpful in easing the transition from an academic to a business environment. Of course they provide formal training designed to add to the individual's basic fund of knowledge. They also provide working experience in a variety of fields and a broad knowledge of the company concerned and its scope of operations. Upon completion, the individual is generally better prepared to decide the direction in which he will pursue his professional career.

General Electric conducts a number of training programs. Those that attract the greatest number of engineers are the Engineering and Science, Manufacturing, and Technical Marketing Programs. Each combines a formal, graduate-level study curriculum, on-the-job experience, and rotating assignments. There is little question in my mind that when an engineer completes the Program of his choice, he is far better prepared to choose his field by interest and by capability. I might also add that because of this, he is more valuable to the Company as an employee.

Q. Then you feel that a training program is the best alternative for a graduating engineer?

A. Not always. Some seniors have already determined the specific field they are best suited for in terms of their own interests and capabilities. In such cases, direct placement into this specific field may be more advantageous. Professional self-development for these employees, as for all General Electric technical employees, is encouraged through a variety of programs including the Company's Tuition Refund Program for work toward advanced degrees, in-plant courses conducted at the graduate level, and others designed to meet individual needs.

Q. For the record, how would you rate a job offer from General Electric?

A. I've tried to get across the need for factual information and a long-range outlook as the keys to any good job evaluation. With respect to the General Electric Company, seniors and placement offices have access to a wide variety of information about the Company, its professional environment and its personnel practices. I think qualified seniors will also discover that General Electric offers professional opportunity second to none—and starting salaries that are competitive with the average offered throughout industry today. From the above, you can see that I would rate a job offer from General Electric very highly.

Want more information about General Electric's training programs? You can get it, together with a copy of Dr. Saline's paper "How to Evaluate Job Offers" by writing to "Personalized Career Planning," General Electric Company, Section 959-15, Schenectady 5, New York.

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