MARCH 1967

ENGINEERING AND SCIENCE

PUBLISHED AT THE CALIFORNIA INSTITUTE OF TECHNOLOGY

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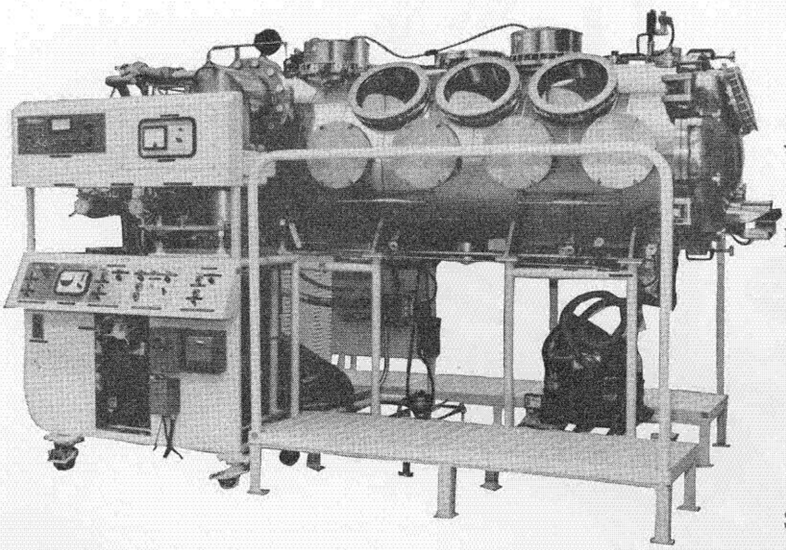

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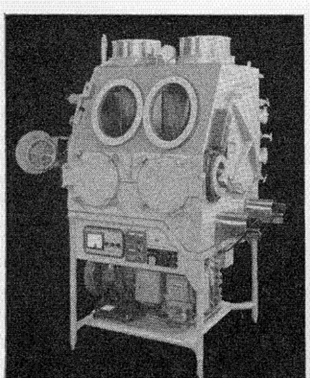

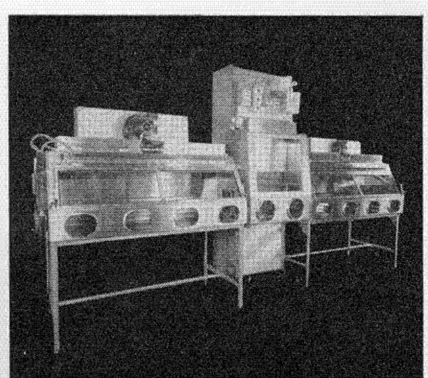

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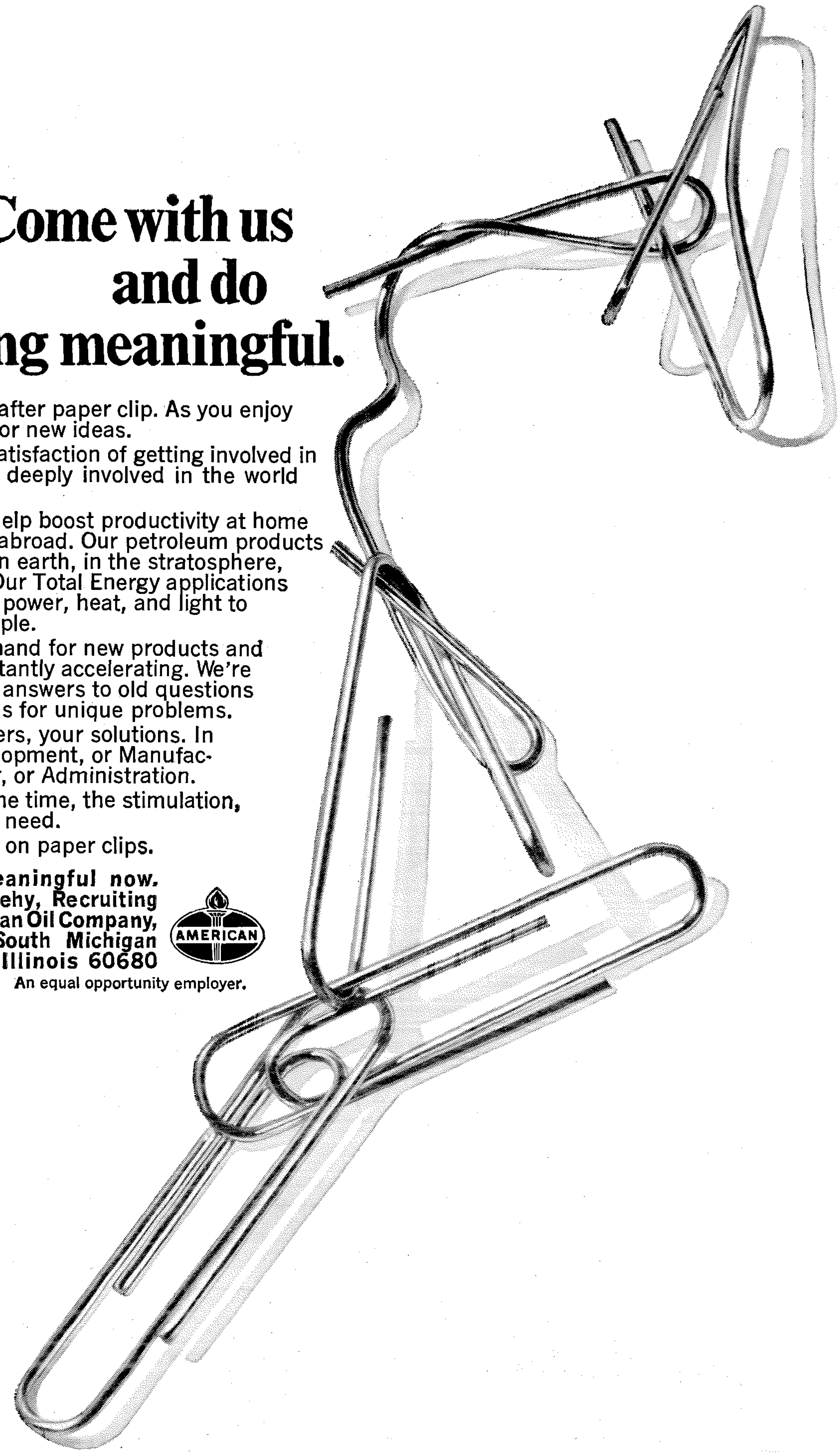

ENGINEERING AND SCIENCE

MARCH 1967 / VOLUME XXX / NUMBER 6

PICTURE CREDITS: Cover, 10, 20–James McClanahan / 14, 15, 16–Robert Edgar / 25 (top)–Gerald J. Trafficanda / 25–Glenn Engebretsen / 33–Kent McCaulley.

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Published monthly, October through June, at the California Institute of Technology, 1201 East California Blvd., Pasadena, Calif. Annual subscription $4.50 domestic, $5.50 foreign, single copies 50 cents. Second class postage paid at Pasadena, Calif., under the Act of August 24, 1912. All rights reserved. Reproduction of material contained herein forbidden without authorization. © 1967 Alumni Association California Institute of Technology.

COVER

Caltech biologists William Wood and Robert Edgar have been accumulating detailed knowledge about how a complicated virus known as T4 builds itself. In the process they have figured out a way to isolate various parts of the virus and then put them together *in vitro* (in an artificial environment) to form the finished, active virus. A report of their work, "How to Build a Virus," is on pages 14-16.

I've worked hard for success but I've never been a slave to my job--

says Thomas L. Thorkelson, C.L.U., Santa Ana, California

"I'm the kind of guy who likes to be independent. That's what attracted me to the insurance business. As a Mass Mutual agent I have the freedom I crave. I can organize my working hours to allow me to spend time with my family in our cabin in the High Sierras and to accept various speaking engagements across the country. I'm able to devote hours each week to serving as a bishop in the Mormon church. I have time for the Santa Ana Junior Chamber of Commerce and our local Boys' Club, and to teach an insurance course at Santa Ana College. I'm not a slave to my job in any sense of the word.

"But don't get me wrong. When I work, I work hard. I prefer to see clients right here in my office. I've found that this gives me much more time to be of service to them. I feel my first duty is to show my clients what life insurance can do and how important it is to an over-all financial plan. Once this is done I help them set up a suitable plan to fit their own individual needs. This involves more than advising them on types and amounts of life insurance. Quite often I find this means calling in their lawyer to advise them on related matters, or suggesting they contact a broker about investing extra cash they may have on hand."

Tom Thorkelson is a 1954 Business Ad graduate of the University of Southern California who has been a Mass Mutual agent for seven years. He earned the Chartered Life Underwriter Designation from the American College of Life Underwriters during his first three years in the business—qualified for the industry's National Quality Award for the past three years—has been a member of the Million Dollar Round Table for the past six years—and is a member of our Company's Inner Circle, the exclusive group of those who place $2 million or more of new individual life insurance in a year.

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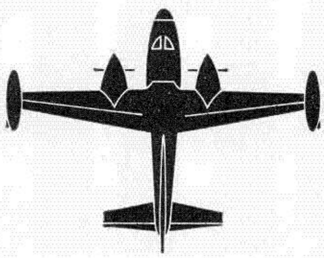

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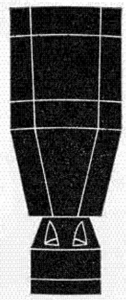

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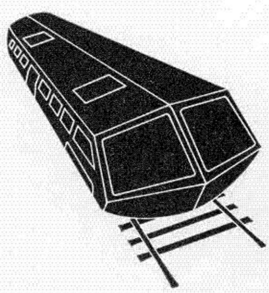

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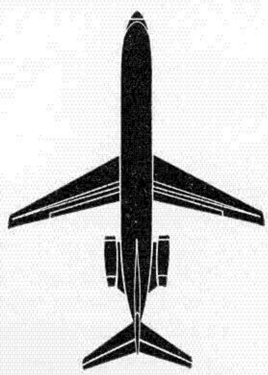

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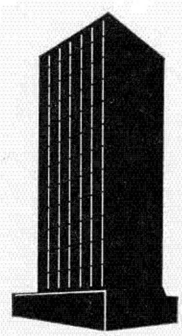

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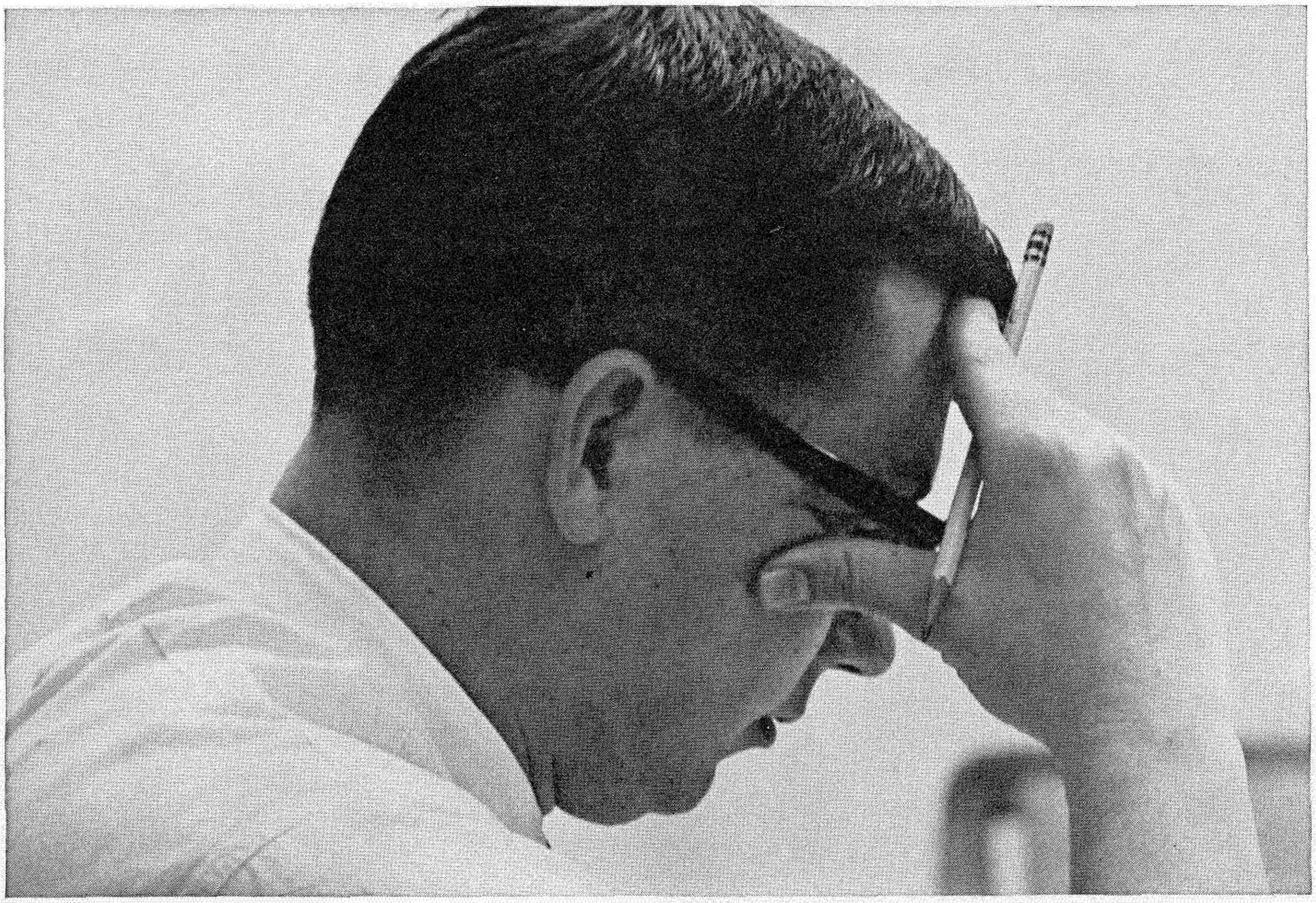

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A distinguished educator examines the past and present responsibilities of higher education and thoughtfully answers the question:

WHOSE UNIVERSITY?

by Rosemary Park

"Whose University?" is an old and recurrent question which arises when the power structure of society changes or when religious and philosophical viewpoints shift. No one today would wish to deny that ours is a changing society in all its aspects. Therefore, the university's relation to society—indeed, the very structure of the university itself—may demand some re-examination.

A few brief historical observations will serve as background for my attempt to answer this perennial question.

Most of us know that of the first universities some were controlled by students and some by faculty. But all which aspired to more than local recognition were licensed by the church or by the state, that is, by either ecclesiastical or political authority. This relationship of the university to the state has been a continuing one, which has provided on occasion protection for the academic group from oppression by the community, but on other occasions has exposed the university to undue influence, even to exploitation by the state itself. Nevertheless, the university has successfully maintained its right to set its own aims within its own constituency. Nor has the state ever desired or attempted to force citizens into the academic life.

Throughout its existence the university has continued to be a voluntary association of members whose aim is the establishment or the discovery of truth. At times I think we would all agree this aim has been poorly stated and misunderstood. Eruptions within the university and tensions without have made the historical account of universities a very lively topic. Through it all, however, argumentation and revolt seem to have arisen, not because men doubted the university's aim was sound, but rather because the evidence for truth itself had shifted.

It takes some courage to enunciate these very general statements today since we are all apt to be concerned more with information than with structure or meaning. Nevertheless, in full awareness of the danger, I shall proceed to make one or two more such statements.

In medieval times, when the universities first arose, truth was primarily determined by the study of revelation as contained in the Scriptures, and as interpreted by councils of the church, through which, it was believed, the Holy Ghost spoke. The agent of this study was human reason, implanted in man by an omnipotent and an omniscient deity. This was a closed system, built on a faith in this omnipotent deity. It was also a system which required a great deal of human reason, as reason endeavored to explicate the truth of revelation.

Time passed, and the power and the authority of the church declined. Concurrently, there was increased confidence that human reason was capable, without revelation, of discovering the truth about the universe and about man. Characteristic of these new times was the statement of a German critic, Gotthold Ephraim Lessing, that, had some deity offered him a choice between absolute truth and the pursuit of truth, he would have chosen the pursuit.

Within universities and among the philosophers and scientists, who at that time were often the same, a method of study gradually developed, founded

"Whose University?" has been adapted from a lecture given by Rosemary Park at Caltech on February 23. Dr. Park, president of Barnard College who will become vice chancellor for educational planning and programs at UCLA in June, spent three days on the Caltech campus last month as a YMCA Leader of America.

Unscheduled talks with students are just as much a part of Rosemary Park's visit to Caltech as her scheduled lectures.

on the assumption that the universe may be comprehended by man's reason alone. This so-called scientific method led to extraordinary discoveries in the physical world, and these successes in turn tended to establish the conviction that the only acceptable evidences for truth were the results of the scientific method. It is, perhaps, a slight overstatement to maintain that this method became as absolute in its claim as the dogmas of the church at an earlier time. If it was not approved by the church council, it was not true. If it was not the result of the scientific method, it was not true.

The basic difference between these two positions is that one operated within a closed system, controlled by an omnipotent and omniscient deity, the other in an essentially open system. I mean by this that we cannot know in advance what the scientific method may bring to light about the universe and man. We cannot be sure, therefore, that this knowledge may not be destructive for man. And since there can be no assurances that the method and its evidence for truth will be favorable to man's existence, to pursue truth by this method requires not only honesty and accuracy but a kind of courage to face the results of investigation with equanimity.

Under the older system, in the words of the New Testament, the truth made men free. Under the modern one, the truth might also destroy. Indeed, it became clear that neither the religious, social, political, nor economic structures of a society could count on support from the universities if their claims differed from the evidence produced by the scientific method. It is significant that the older system spoke of "error" and the newer speaks of "failure."

Since error could lead to eternal damnation, its existence implied moral as well as intellectual weakness. Failure, on the other hand, meant nothing worse than disappointment—an indication that the second, third, or even fourth try should be undertaken, no value judgment having been made. The critical spirit of this new method dissociated itself for the most part from moral judgment and proved a firm ally in undermining the traditional structures of an aristocratic and feudal society.

The scientific method had results other than the shaking of the traditional beliefs about man and his world. The facts it discovered about the universe could be exploited technologically, and in time they produced an affluence hitherto unknown in any society. In proper concern for the physical welfare of its citizens, the secular state encouraged the establishment of universities, so that knowledge might increase and be applied to raising the material well-being of the community. Thus, the university became the courted handmaid of economic and political interests, while at the same time it was suspected of subverting many of the traditional values.

Since the university's production of knowledge continued to bring wealth and health to increasing numbers of people, it was natural that the possibility was examined of encouraging the material advance which the university made possible, but of containing, somehow, the havoc which its knowledge wrought in religious, political, and economic orthodoxies. In very recent times, some governments have forcibly intervened to this end and have dared to prescribe the areas and the results for which the university was to be responsible.

This was a time of martyrs, such as the university had experienced occasionally before and not unlike the ages of persecution the church had known in its history. In Russia and Germany, the state endeavored to define the university's aims and to subvert the search for truth as determined by the scientific method. Persuasion and violence were used to enlist the university's support in sustaining a given ideological structure.

To some areas of the university instruction and study, this imposition of new aims from without did not seem to matter, because the knowledge these disciplines produced under the scientific method did not impinge upon the ideological or traditional value area itself. The specialized learning of the times permitted a man to work with good conscience in his laboratory or at his desk, while the society about him collapsed. Some men suffered for their convictions about the nature of truth and evidence. Others, almost equally honest and accurate, continued their investigations using this same method, but untouched—or at least unmoved—by the destruction of their colleagues.

Some of us remember these times. In Germany, the social, political, and economic structure had been eroded from many causes. The university was forced to support a desperate and evil system and was given no choice except such as it had convictions and power to enforce. But on political and social issues there was no single conviction. Instead, there were voices within the university from the extremes of right and left—some, too, from the center. The university, then, could not honestly speak with one voice. It had no power except through extra-university channels, and these were blocked by dictatorship.

Of immense significance is the fact that, at this point in time, many people expected the university to be a bulwark of strength against the evil of the times, and the university was not. It could not be.

The problem for us today is not very different in kind, though perhaps it is in degree. The universities are the most influential centers of modern intellectual life. They supply the knowledge which undergirds our economic and governmental system. Without them our civilization would freeze in its present form and atrophy into the timeless fellahin culture Spengler foresaw for those civilizations in whose midst great decisions are no longer made. To avoid such a withering away, the scientific method must continue to increase basic knowledge, to challenge yesterday's solutions, and to dredge up the forgotten and unobserved facts which can undermine confidence in the accepted answer.

But what about the pattern of society within which this university exists?

As the knowledge explosion becomes a commonplace, I think I hear people saying to our universities: If you know so much, why don't you know more? This is a very moving question, because it arises from the same kind of need which had raised hope in Hitler's Germany that the university could resist. With us it is not resistance which is required, but vision. Our community has not disintegrated like the middle European world of the thirties. But many of our young people are alienated from, or neutral toward, their society. They press the university to take a stand, to define the good life, to say what should be done to create justice. And in answer we talk to them about honesty in observation, care and accuracy in tabulation, and courage in facing the results—all these things which characterize our method for ascertaining truth.

The question we need answered is not "How can we do?" but "What should we do?"

To these questions the university seems to reply that such things are practical matters which each man must decide for himself as best he can. This is an honest answer. It overlooks the fact, however, that there is no other institution today which can give a reply. When the church answers, it does so from different presuppositions, and it is an institution with the weight of the past great upon it. The family can speak of what was, but it is at best uncertain about this new generation which—though it is inexperienced—finds it relatively hard to listen and yet is seldom at a loss for an opinion.

The university must, nevertheless, take the question of priorities and goals seriously and must study in all humility and earnestness its resources for responding. It has an honest method for ascertaining truth. It has men and women whose integrity in the use of this method is beyond reproach. It knows too that it deals primarily with intellectual matters and can observe that the questions at issue today come from a different sphere of experience, in which the scientific method may not now be productive. At least no one yet maintains, I believe, that the scientific method can establish ethical priorities.

In this dilemma the university might do well to remember a famous distinction of Plato's, the distinction between truth and right opinion. Experimentation as an essential aspect of the scientific method can validate truth. An experiment is repeatable. It follows that truth, once proved in this way, can be demonstrated at will before any audience. Right opinion, however, can only be communicated. It is not founded on logical structure or experiment; it is not the product of the scientific method. It seems to me, however, that those who have studied and learned—and have the courage to face the results of their experiments, as the scientific method requires—are best able to express opinions on matters which may not be susceptible to their kind of proof.

On social and moral priorities the university itself will seldom be able to take a stand, because these priorities are not subject to establishment by its kind of evidence. This does not mean that teachers and learners should not express opinions, provided that they are mindful of the tests these opinions may be subject to and of their commitment to accept the results of these tests, even when they upset a dearly-loved position.

Plato said that right opinion was a gift of God, which implies, I think, that not all opinions expressed will be right opinions. It is a weighty responsibility to give opinion. And yet, I believe we must answer when questioned, making it clear that what we say is opinion and not truth—that it is our opinion and not the university's. To speak in this fashion takes courage not unlike the courage required to face the results of scientific experimentation.

The university itself must stand for truth in the highest form. This means that it cannot take a position on all matters which are of ultimate concern to us as a society and to us as individuals. On those matters the man and women who belong to the university must feel free to speak, and the university must exert itself to see that they are free. Consequently the university will abound in personal statements, some of which can be tested by our methods for discovering truth; the rest will remain opinion.

Does this mean that the vision we seek cannot be expected from the university, except as informed opinion, and that the university can no more see ahead in our time than it could defend itself from the attack of a desperate society under Hitler? To answer this question a little more clearly I must make a concession. I have so far concentrated on those aspects of the scientific method which are intellectual and critical, which concern the examination of data and the verification of conclusions. This was the revolutionary aspect of this form for truth. I have overlooked, however, an essential aspect of the method—namely, the setting of the stage for the experiment, the establishment of the hypothesis.

I have said that our need today is for vision and not for resistance. It should not be forgotten that the kind of knowledge which we foster at the university begins with a supposition, an imaginative assumption: Suppose this were true; what would follow?

Most students probably never experience the joy or the excitement of setting up these assumptions in their undergraduate science instruction. And so they need to find creative experience, perhaps in other areas, if they are to develop and stretch their imaginative capacities. Out of this experience of setting the hypothesis, and with the help of men and women of right opinion, some of the questions directed at the university can be responded to for a a while. These answers, however, can be nothing more than hypotheses, because they are subject to further examination and observation. We can act as if the hypothesis were true. We can act as if justice were possible, as if love as well as logic were built into the structure of the universe. But I do not think we can prove that these things are so by the only method available to us today.

The university provides us a method which is not totally applicable to all human experience. Some of us believe that ultimately it may be. This is a kind of faith and one which has moved men to great sacrifices. The power to set the hypotheses for the future is within the university's capacity, and we need only to strengthen this power in our students.

Today students have learned our critical techniques too well, and in a kind of frustrated idealism they have turned this knowledge against the one social institution which could help them find a juster and a more honest world.

So then, whose university is it? My answer will be equivocal at best.

The university belongs to no one—not to the students, who seek to remold it, perhaps before they have honestly examined it; not to the faculty, whose studies and investigations demand so much attention in the midst of the present explosion of knowledge; not to the administrators, who try to preserve its freedom amid the pressures from within and without; not even to society, which is called to support it at ever increasing cost and which succumbs periodically to the temptation to make it serve not truth but the establishment.

While all this is true, I believe that if any of these groups ceases to need the university or to care about it, it could wither away. They are all essential ingredients, but not in themselves controlling factors. The university is like the church which preceded it: an institution which directs its attention beyond the immediate present and beyond the existing society. It attempts to prepare students for the future, a world it cannot know. Its faculty are producing the innovations which will change the present. Like the church, it must be autonomous and free from the control of those who may wish it to serve some other cause than the discovery of truth. Unlike the church, however, it does not condemn in perpetuity. It may fail to make its method clear. It may not find men of right opinion who address themselves to present issues fearlessly and with serious purpose. Society may succeed in forcing it to undermine its discipline for a time, but when the threat of violence is removed, it returns to its original purpose.

Society may fear the unfettered search for truth which is the university's program, but unless it supports the university on the university's terms, it cannot be assured of the innovations a university program makes essential for its continued development. The church relied on her power to bind in heaven and on earth. The university has no such ultimate power, nor the desire for it. Its more modest aim is to be the primary instrument for growth in the society—by furnishing a method for arriving at truth and by offering, in addition, a place where opinion and hypotheses about the future can be presented and examined with courage and imagination The university, therefore, is an institution which belongs to no one but is essential to all.

In providing for his daughters, John B. Kelly stated in his will that what he was about to give them would *"help pay dress shop bills which, if they continue as they have started under the tutelage of their mother, will be quite considerable."*

For information on how you can provide for Caltech and pay for the dress shop bills as well, contact:

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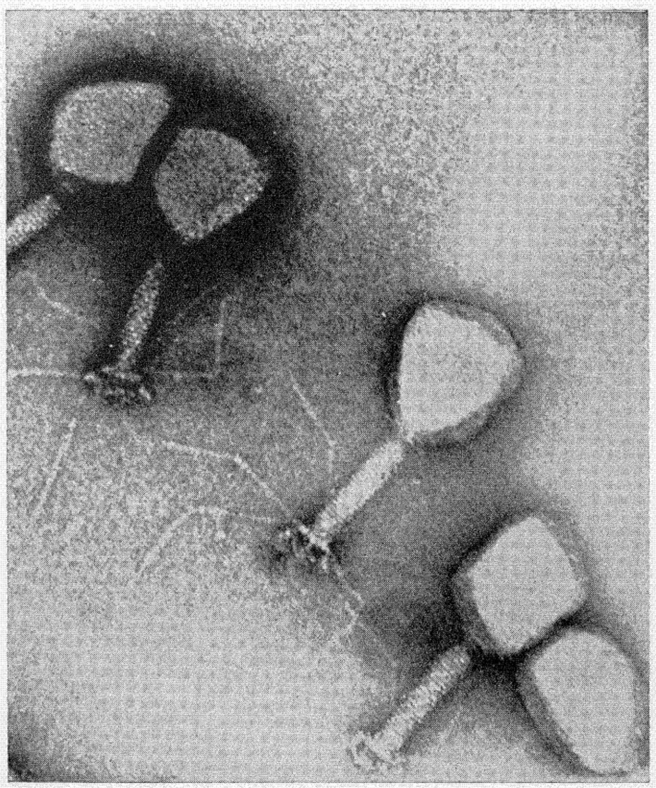
HOW TO BUILD A VIRUS

Caltech biologists take an exciting step forward in genetic research by constructing a virus in the laboratory.

Two Caltech biologists have figured out the orderly sequence of steps involved in the reproduction of a virus and have duplicated this reproduction in the laboratory. Robert Edgar, professor of biology, and William Wood, assistant professor of biology, have put together the virus known as T4, a larger and far more complex virus than the first one created in an artificial environment (tobacco mosaic virus) by biologists at Berkeley ten years ago. Drs. Edgar and Wood based their work on previous investigations by Edgar and collaborators at the University of Geneva.

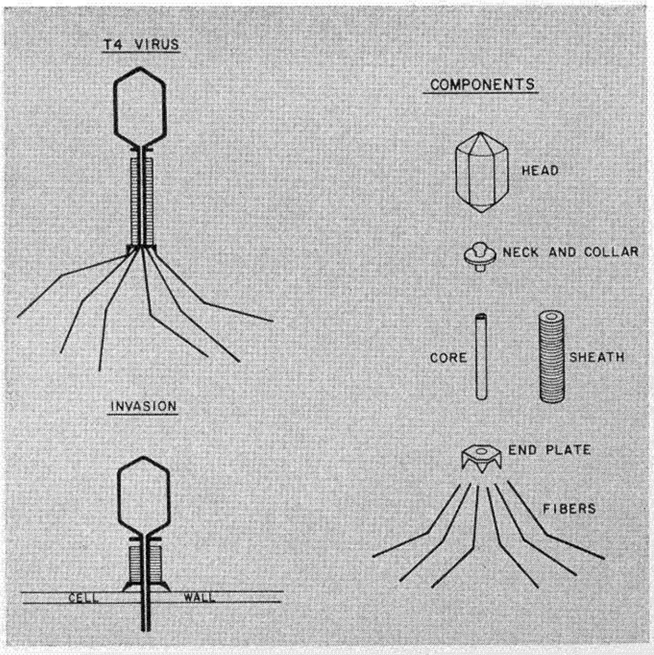


The heads, tails, and endplates of these T4 viruses can be clearly seen in this photograph taken with an electron microscope. The tail fibers are also visible. Magnification is about 200,000.

T4 consists of a head, which contains DNA (the blueprint for reproducing the virus), and a rather complicated tail. The body—head, collar, core, sheath, endplate, and fibers—is no more than a fancy syringe for protecting the DNA and getting it inside another cell. Once the DNA enters the other cell, the machinery of the host translates the plans encoded in the virus DNA into new, finished viruses. In the case of the T4 virus, the host cell is *E. coli*, a harmless, common bacterium found in human intestines.

Inside the *E. coli* the T4 destroys the DNA of its host, allowing its own DNA to take control of the cell. The host cell then starts producing about 100 different kinds of proteins needed to make more T4. After about 30 minutes the cell, filled with T4 viruses, bursts, liberating about 100 live virus particles.

To learn how T4 is assembled, Dr. Edgar and his collaborators at Geneva had to determine the roles played by individual viral proteins. They knew that one way to do this would be to prevent the T4 from making one particular protein, then let the T4 infect a host cell, and observe the consequences of the infection. Since the proteins are made by genes (which are segments of the DNA that encode information), a mutation in one of the 100 genes of T4 could block production of a protein. For example,



To reproduce itself, T4 uses its tail fibers to attach to an E. coli *bacterium, then contracts the sheath, which inserts the core through the wall of the host cell. DNA stored in the virus head is then injected into the* E. coli.

if the DNA had faulty instructions for making a particular protein of the virus head, one might expect that when the host cell burst, tails—but no heads—would be liberated by the host cell.

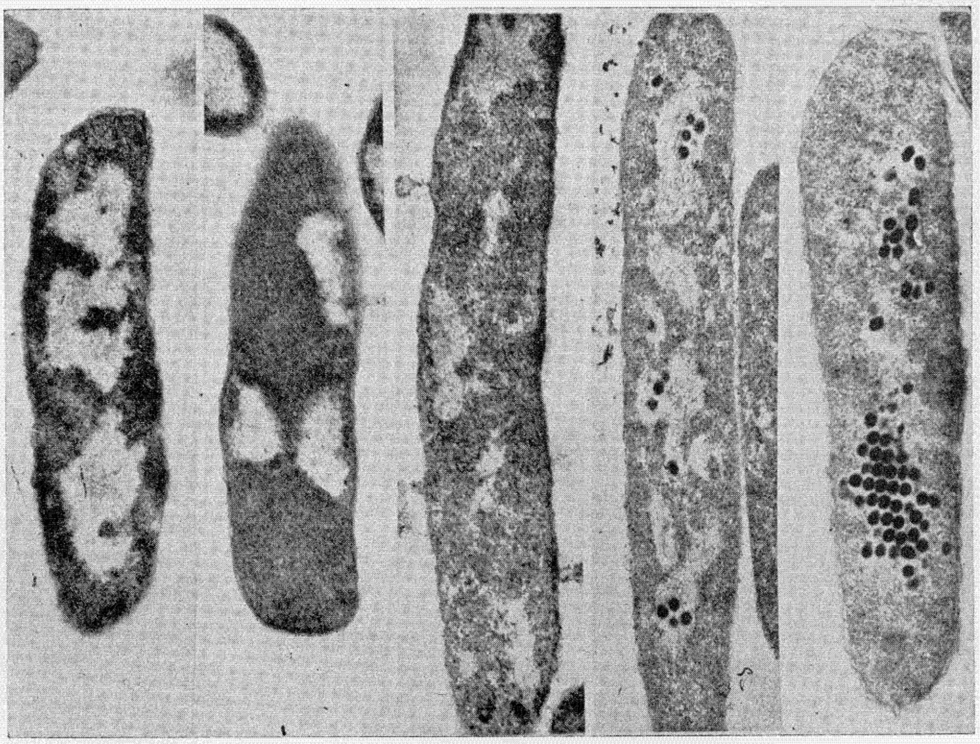
But this kind of typographic error in the DNA code would be the end of the line (or "lethal") for that virus, because it would be unable to reproduce itself further. Since it is necessary to culture a particular mutant strain through many generations, the scientists had to employ "conditional" lethal mutations—those that are lethal only under certain conditions, which can be controlled.

An example of a conditional (but not lethal) mutation is found in the Siamese cat, which has a gene that controls an enzyme that makes black pigment. But the enzyme that is made is sensitive to temperature, so the pigment is only made in the extremities of the cat's body, where the body temperature is slightly lower than in the rest of the body. Hence, the cat has black ears, tail, and paws. This is known as a temperature-sensitive mutation. Obviously, if that mutation had affected proteins that were necessary for reproduction rather than for pigmentation, then they would be conditional lethal. This is but one example of many kinds of conditional lethal mutations which exist.

Because natural mutations occur infrequently, the T4 virus was treated with chemicals to increase its mutation frequency, and a large number of conditional lethal mutations in T4 were found. These mutations occur randomly among the genes of the virus, and the mutations serve as "tags" for the different genes. The mutations can be sorted out by a variety of different tests and the relative locations of the different tagged genes determined.

To find out what a specific gene does in the process of making T4, Dr. Edgar allowed viruses that were defective in that gene to infect bacteria under conditions where the gene would not work. He then found that in one case no virus DNA was made after infection, suggesting that the defective gene was involved in making the DNA. In other cases he

The infection of E. coli *by T4: (a) Before infection—white areas are DNA of the* E. coli; *(b) After infection—DNA of the T4 destroys DNA of the* E. coli; *(c) DNA of the T4 replaces DNA of the* E. coli*—the infecting particle is still attached to the cell wall at the upper left; (d) Black spots are newly formed T4; (e) T4 continues to form—about 30 minutes after the original infection, the host cell will burst, liberating the new T4.*



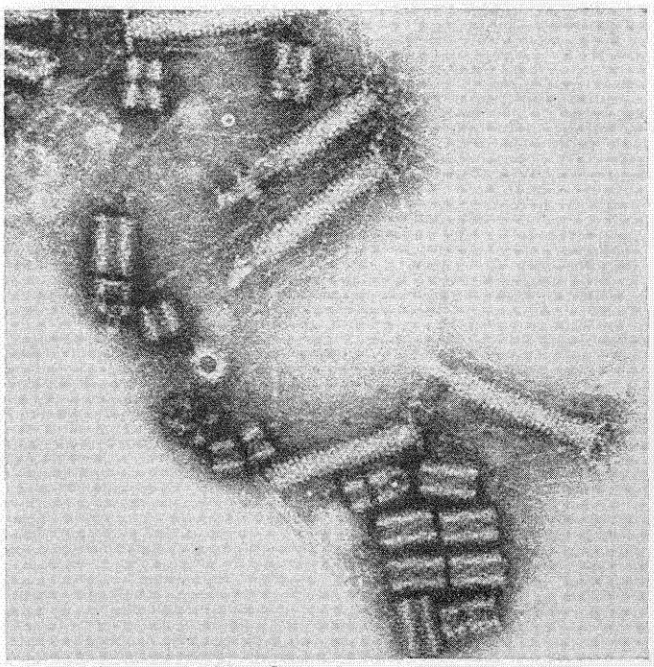
found that the bacterial cell burst open and liberated only heads, or only tails, or perhaps heads and tails not connected.

About 70 different genes in the virus have been identified so far; Dr. Edgar estimates that this is roughly half the total number of genes. This represents a considerable knowledge of the genetics of T4, considering that only about 100 of perhaps 100,000 human genes are known.

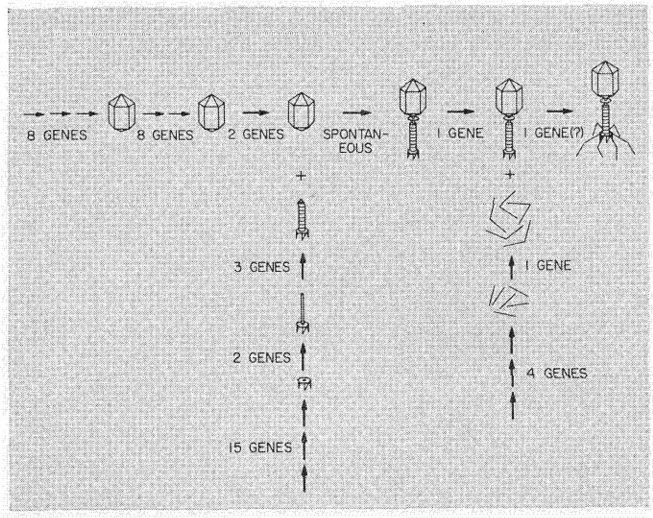
Eventually a genetic map evolved showing the specific or general functions and the relative positions of the identified genes on the DNA. It surprised Dr. Edgar to find so many genes (about 45) that seemed to be concerned with building the virus. Although complex, the virus appeared to be composed of fewer than 45 different proteins. Clearly, the construction of the virus was a more complex process than had previously been envisaged.

To learn more about how the virus used so many genes in its assembly, Drs. Edgar and Wood decided to use the various mutants as a source of virus parts and try to build a virus outside a host cell. They began by taking virus particles which, because of a specific mutation, lacked tail fibers, and mixed these defective particles with an extract from *E. coli* cells infected with another mutant chosen to produce the tail fibers but not virus particles. The result was active virus particles with tail fibers. The next step was to connect heads to tails and then attach fibers, and this too was successful.

From experiments of this type they built up a



Drs. Edgar and Wood used a mixture of tail components like this as a source of supply for building a virus. It contains sheaths with endplates, sections of sheaths showing the center holes for cores, a sheath on end (middle), a core on end (right), and tail fibers.



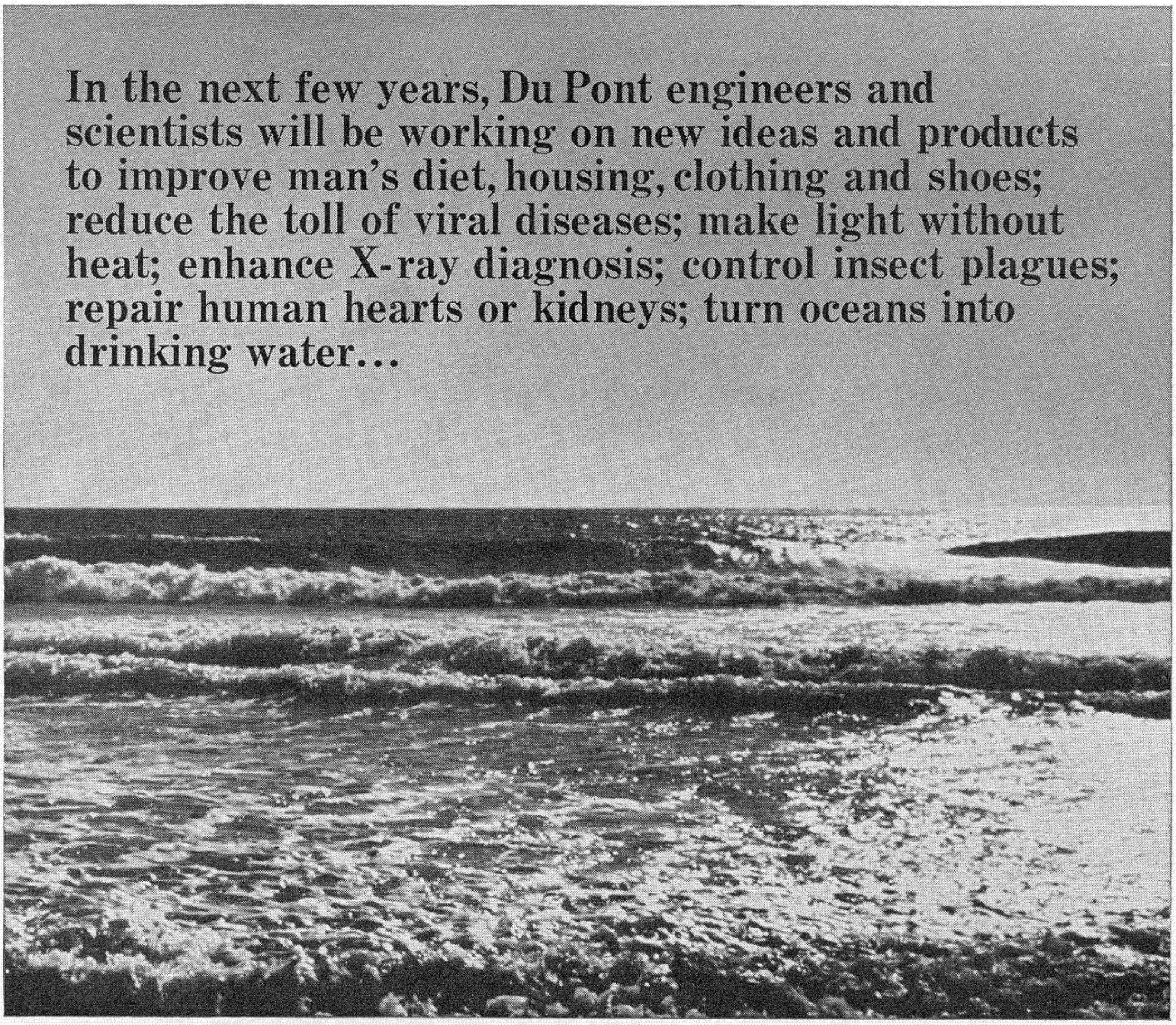
It takes at least 45 different genes to direct the assembly of a T4 virus, which is put together in an orderly, step-by-step process.

scheme for how the virus is put together. It suggests that the virus is assembled in a step-by-step manner, with each step under control of a different gene. There are at least eight genes involved in building the basic head, with eight more that make proteins for finishing the head. (These probably make the little neck and collar section.) Finally, there are two more that finish the head and make it possible for the head to attach to the tail.

Fifteen genes and, thus, 15 different proteins are used in making the complicated endplate. Two more genes make proteins needed for tacking on the core to the endplate. Once the core is on, three genes make proteins for the sheath, which assembles around the core, finishing the tail. At this stage the assembly will proceed spontaneously, with the heads and tails joining; none of the other steps has yet been found to go spontaneously.

The fibers are built independently of the head and the tail. Four genes are concerned in making half fibers, and a fifth joins the half fibers together. One more attaches the fibers to the tip of the tail.

In spite of the wealth of knowledge now in existence about T4, there is still a great deal of mystery surrounding the processes that Drs. Edgar and Wood have been studying. There are many genes whose functions are not known. Moreover, the manner in which the various genes work in assembling the virus—aside from the general knowledge of what steps in the process they affect—is unknown. Do the genes make different proteins which then join together in sequential steps, or do some genes make enzymes that help to join different parts of the virus? Understanding the chemistry of the assembly process constitutes a substantial task for the future.



and anything else that you might think of.

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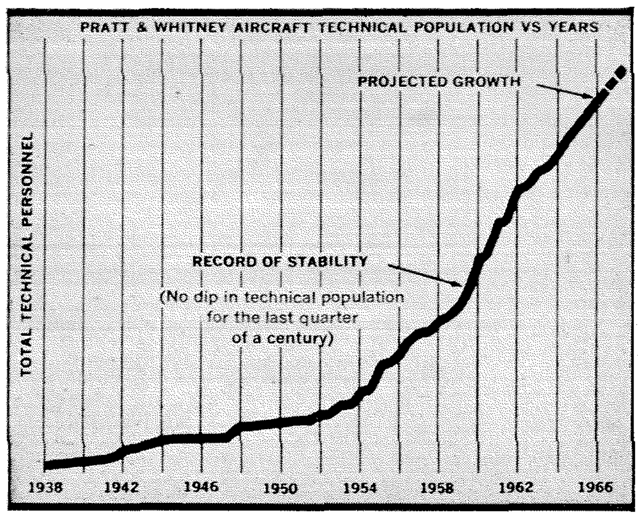

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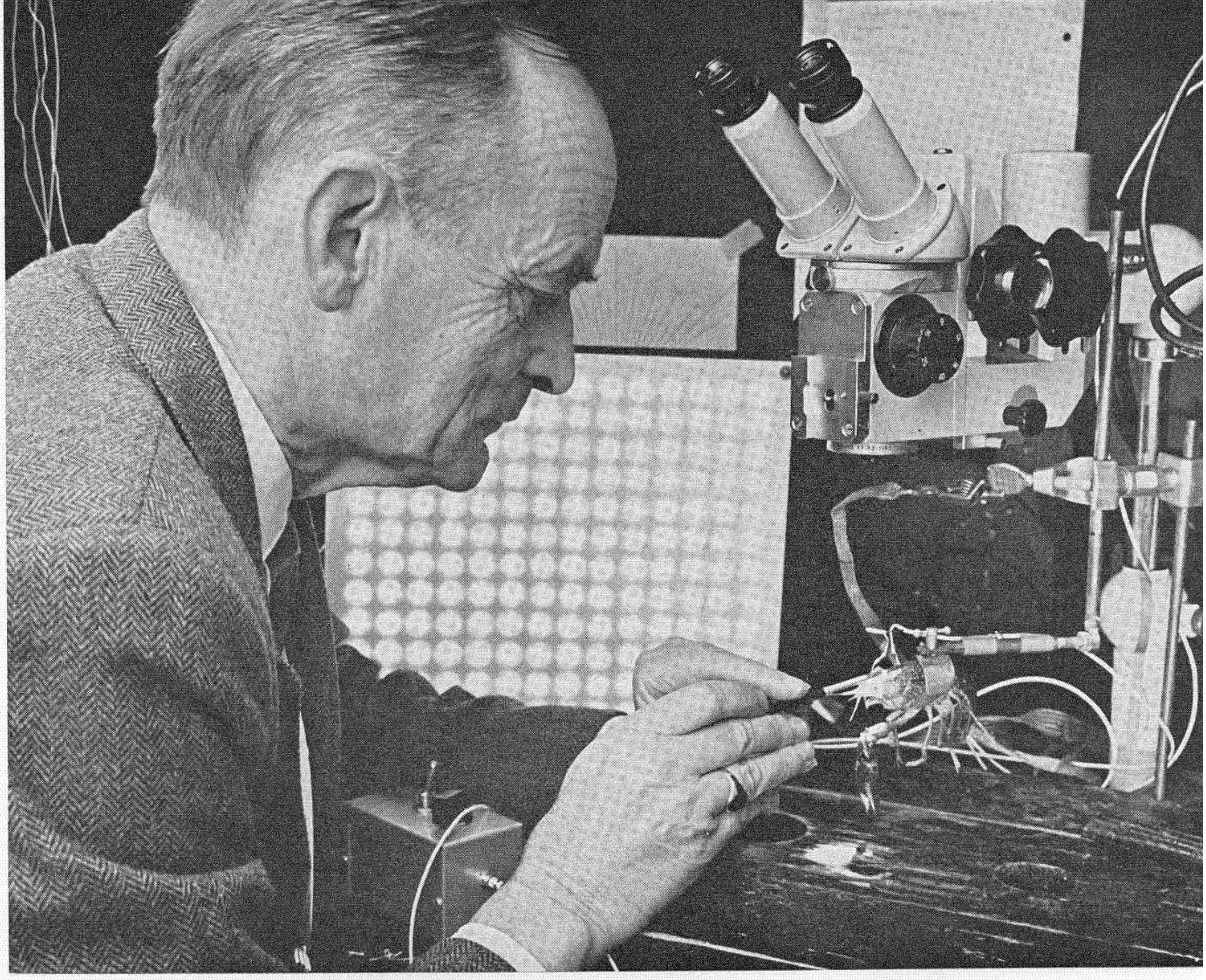

C. A. G. Wiersma measures the electrical impulse responses of the crayfish to touch.

LOOKING INTO SEEING

The freshwater crayfish is making a unique contribution to science at Caltech. C. A. G. Wiersma, professor of biology, who has uncovered valuable information about the central nervous system in past studies of the crayfish, is now in the midst of an investigation of visual integration in the crayfish.

Dr. Wiersma is finding out how and what the crayfish "sees" by registering the information it sends from its eyes to the brain via the optic nerves. These messages are sent in the form of electrical impulses along one or more of the 17,000 separate fibers that make up each optic nerve. Some of the fibers carry impulses from the eye to the brain, some from the brain to the eye, some in both directions.

In his investigations into the nerve circuitry of seeing, Dr. Wiersma has been able to identify several specialized kinds of fibers, to map their locations, and to describe their function.

The space-constant fibers, one of these kinds, report to the brain only what is seen by the part of

A Caltech biologist investigates the nerve circuitry of seeing by studying the complex optic nerve system of the simple crayfish.

the eye looking toward the sky—no matter which way the crayfish is turned. Apparently these fibers are linked with the crustacean's organs of balance—two small, hollow bowls called statocysts—located at the base of the smaller of the two pair of feelers. These bowls are lined with tiny hairs, each connected to a separate nerve ending. A small amount of granular dirt, congealed into a statolith and attached to the hairs, bends them in accordance with the pull of gravity. As the crayfish turns in any direction except horizontally, this pull shifts to affect different hairs. The nerve fibers in the hairs keep the brain informed about the position of the crayfish in its relation to the stream bed.

This information, transmitted to the space-constant fibers, is probably what causes the field of vision to change so that the fibers continue to report only what is seen by the crayfish in its area of sight pointed toward the sun.

The sustaining fibers are another fiber type identified by Dr. Wiersma. There are 14 of these in each optic nerve, and they react to light with a continual discharge of electrical impulses as long as light is seen. Each fiber relays information from a different part of the eye by indicating how much light that part is receiving.

The dimming fibers are still another type found in the crayfish. These fibers convert the amount of darkness into impulses, and they function especially when the crayfish is in dim light. The more the light decreases, the more active these fibers become. When light increases, the fibers stop firing electrical impulses, at least temporarily.

The jittery movement fibers, a fourth kind, are evidence for the presence of a biological computer mechanism in back of each eye. This mechanism can predict the rate and direction of any object that passes in front of it. As the eye sends the necessary messages to the brain, the tiny computers intercept them and use them to calculate, in a fraction of a second, the rate and direction of the object's movement. As soon as this information is available, the computer switches off the impulses in the movement fibers. But if the moving object changes its speed or direction in any manner not predicted by the computers, the switch is thrown on again, and the fibers' discharges resume.

Of the total of 17,000 nerve fibers in the crayfish, some 7,000 are sensory fibers leading to the eye from the fine hairs that cover much of the creature's front parts. Although the investigators do not know why these hairs are linked with the eyes, they may have some function similar to that of the hairs in the statocysts.

Dr. Wiersma has gathered information about only 150 of the remaining 10,000 fibers. He believes that a large number of those yet unidentified are used for purposes other than vision—for example, a large number may be involved in the secretion of hormones.

The way in which individual fibers of the optic nerve are studied involves injecting a needle into the optic nerve and shifting its tip cautiously until a good response is picked up from only one or two fibers. This needle electrode, which measures about 1/25,000 of an inch in diameter at the tip, is coated so that electrical contact is limited to the tip. It then picks up the impulses moving along the fiber. These impulses are amplified and transmitted to an oscilloscope, a loudspeaker, and a digital counter. The information is then computed and used to map the location and function of the fibers.

The crayfish can be induced to respond to outside stimuli by having an object or light source passed in front of its eyes. Other responses can be evoked by lightly touching a part of its body. The number of electrical impulses recorded is related to the effectiveness of the stimuli.

Dr. Wiersma began working with the crayfish when he was a graduate student in Holland in 1928. These crustaceans are particularly well suited to his present visual integration research. They are plentiful in southern California; they maintain their optic reactivity after months of captivity and experimentation; and the fact that their eyes are located on stalks that contain the optic nerve fibers makes it comparatively easy to tap them.

What Dr. Wiersma is learning about the crayfish brings science nearer to an understanding of the basic principles of sight in other creatures, including humans.

Dr. Wiersma's current work is supported by the National Institutes of Health and the National Science Foundation. He has been assisted by Joan Roach, research assistant; Ken Hollis, electronic specialist; and T. Yamaguchi, formerly a Caltech research fellow, now at Hokkaido University in Sapporo, Japan.

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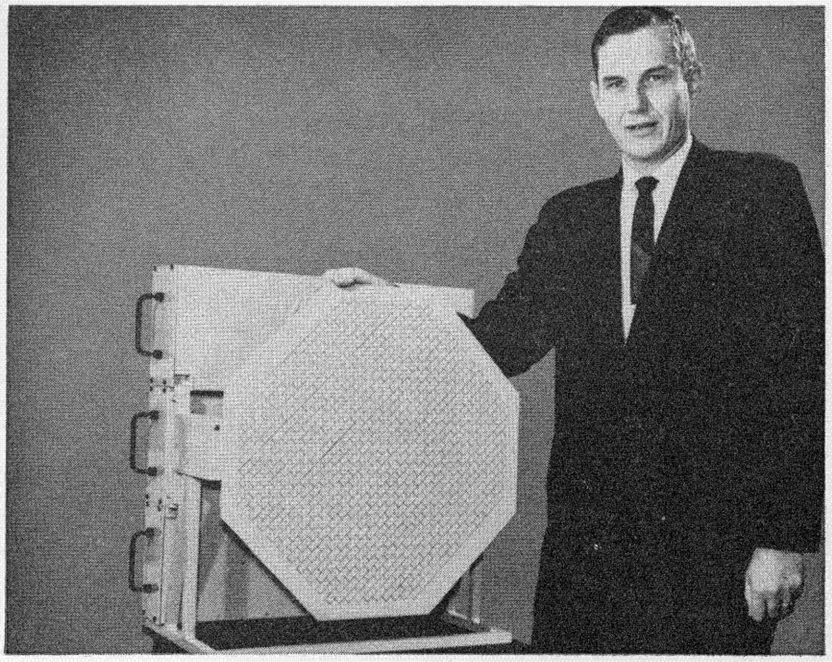

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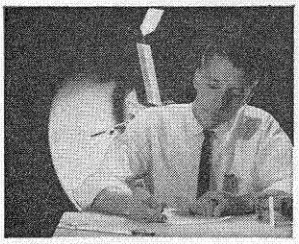
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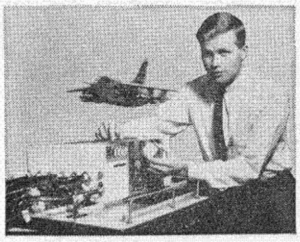
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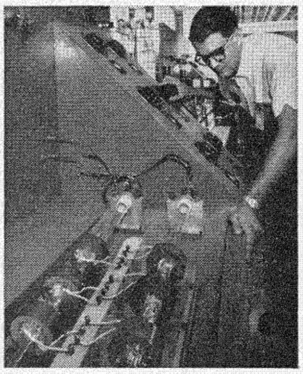
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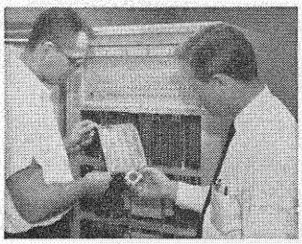
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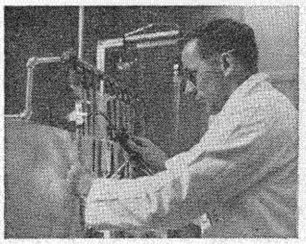
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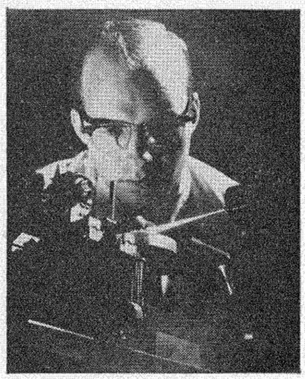
COHERENT OPTICS

Microelectronic radar is a radically new kind of airborne radar now being developed by TI. Called MERA, it will operate far more reliably than the most advanced conventional radar and will provide new performance capabilities as well. The MERA concept profits from long experience in radar design and manufacture. More important, it is a creative design program drawing key scientific and engineering personnel from a number of diverse technologies including systems design, digital systems, semiconductor design, and materials science. As a result, this new radar needs no high-power microwave source and has no moving parts — a creative problem solution that never would have resulted from a conventional approach. Coordinated management of many technologies, such as those illustrated here, is one reason TI has doubled in size about every three years for the past 20 years. This growth and diversity offer exceptional opportunities for outstanding college graduates at all degree levels and in many disciplines. For a free brochure about radar technology at Texas Instruments — or any other technology illustrated here — write Jack Troster, indicating your area of interest. To obtain information about current professional openings, consult your college placement director, or send your confidential resume to Jack Troster, Dept. C-487, P. O. Box 5474, Dallas, Texas 75222. An equal opportunity employer.

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THE MONTH AT CALTECH

HONORS AND AWARDS

Caltech President Lee A. DuBridge has been given the Award of Merit by the Los Angeles Junior Chamber of Commerce in recognition of his contributions to science, educational television, and education. This top civic award is given annually for meritorious and outstanding service of public benefit to the community.

Eugene M. Shoemaker, Caltech research associate and a U.S. Geological Survey Scientist, has been named the 1967 recipient of the Arthur S. Fleming Award. This award is given annually to outstanding men in the federal government who are under 40 years of age. Dr. Shoemaker has been chief scientist at the U.S. Geological Survey's Center of Astrogeology in Flagstaff, Arizona, since 1961. During this time he has led an intensive program to map the moon geologically and to study its composition, structure, and geologic history.

Frederick C. Lindvall, chairman of Caltech's division of engineering and applied science, is one of five men to receive a 1967 Engineering Alumni Award from the University of Illinois College of Engineering. The awards are given to alumni or former staff members of the university "who are distinguished as a result of their outstanding leadership in engineering, industry, or public affairs . . ." Dr. Lindvall was selected for his contributions to the modernization of engineering education, to teaching, and to professional societies.

Sheldon K. Friedlander, Caltech professor of chemical and environmental health engineering, has been named to the first editorial advisory board of *Environmental Science and Technology,* a new monthly publication of the American Chemical Society. The magazine will present comprehensive reports and research papers on man's environment and its control, with special emphasis on water, air, and waste chemistry.

THE NEXT NINETY YEARS

When Caltech professors James Bonner, Harrison Brown, and John Weir wrote *The Next Hundred Years* in 1957, they never expected to have to revise their long-range predictions in only ten years. At a conference held at Caltech on March 7 and 8, however, they did just that—assisted by professors Norman Brooks and Thayer Scudder.

The Next Ninety Years, a conference sponsored by the Office for Industrial Associates of the Institute for representatives of business, industry, and government, featured a panel discussion by the five experts dealing with new factors of population growth and technological development. These factors have caused them to make vast revisions in their predictions about the future of the world's population crisis and technical-industrial culture.

World population, estimated in 1957 to grow to 3.3 billion by 1980, reached that number two years ago. By the year 2000, it will be 7.5 billion. This undreamed of rate of increase makes the threat of starvation more ominous.

Other conference speakers who discussed the problems of overpopulation and hunger and the challenge of environmental pollution control were J. George Harrar, president of The Rockefeller Foundation, and Athelstan Spilhaus, dean of the Institute of Technology, University of Minnesota.

HAYNES FOUNDATION LECTURES

Charles W. Yost, a senior fellow of the Council on Foreign Relations in New York City, comes to Caltech next month as Haynes Foundation Lecturer on April 18, 19, and 25 in Dabney Lounge. Mr. Yost, who was deputy permanent representative to the United Nations from 1961 to 1966, will speak on "The Prospect for Stability in the World Today." This is the fourth such lecture series presented at Caltech in the last 10 years. The Haynes Foundation supports research in the social sciences and visiting lecturers at California universities.

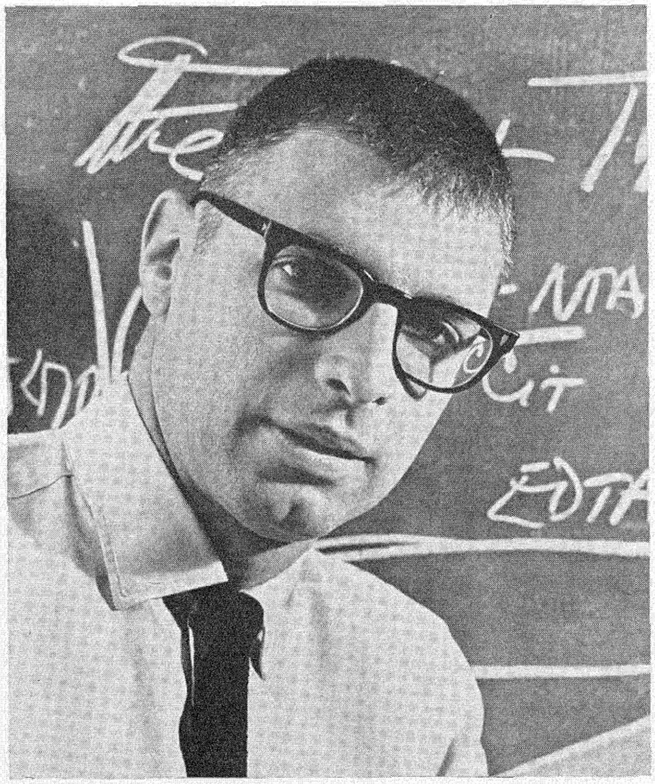
PROVOST FROM CALTECH

Paul D. Saltman, professor of biochemistry at the University of Southern California, has been appointed provost of Revelle College at the University of California at San Diego. The appointment, made by the University Board of Regents, is effective July 1.

Revelle College has an enrollment of about 2,000 students and is the first of 12 colleges that will eventually make up the UCSD campus. The second, John Muir College, will open in the fall of 1967.

Dr. Saltman received his BS in chemistry from Caltech in 1949. After a year of graduate research at the College de France in Paris, he returned to the Institute and received his PhD in biochemistry in 1953. He then joined the faculty at USC as an instructor in biochemistry. He was named assistant professor in 1954, associate professor in 1958, and professor in 1961.

Although he is active in both undergraduate and graduate teaching programs at USC, Dr. Saltman is especially concerned with the problem of making scientific developments clear to the layman. He has worked on a number of television programs interpreting biology for the layman and has presented several radio programs dealing with the need for creative scientists.



Paul D. Saltman, professor of biochemistry at USC.

TO A YOUNG SCIENTIST

"What are you going to finally own at the end of your life span? I will tell you exactly what you can own. You are never going to own any of your friends, never going to own any of your relatives; you are never going to understand your mother or your father, or any of your friends, or wives or husbands. You are never going to own the house you live in; it's a place you stay in on your way to the other side of the abyss. But what at the end of your life are you going to own? Your work. That is all you are ever going to have. So you damned well better get in and find out more about it and fall in love with it so that it really becomes yours."

This counsel from Ray Bradbury, fiction writer and "teller of tales," was offered to Caltech students at the YMCA Freshman Dinner Forum on February 24. Bradbury entertained, advised, cautioned, encouraged, and, in conclusion, wished his audience ". . . . a fantastic, exciting, and revealing search—great, great emotion and the cycling round of intellectuality and back out to emotion again . . ."

NEWS FOR ALUMNI

Caltech alumni, who now number more than 9,000, will receive the first issue of an alumni newspaper in April. *Caltech News* will be published every other month from October to June.

The new publication makes its appearance as a result of an eight-month study of alumni-Institute relations conducted last year by a group of 25 Caltech alumni from the classes of '26 to '58. The new eight-page newspaper will be produced by the Institute in cooperation with the Alumni Association.

Ray Bradbury . . . encouraging . . . cautioning . . . advising . . . entertaining . . .

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

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

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

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

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

The President

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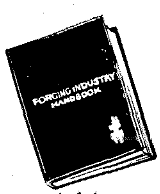
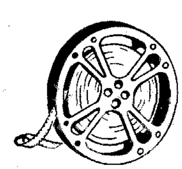


New hardbound 520-page *FORGING INDUSTRY HANDBOOK*, describing forging design, applications and technology, is available to students at special low price of $2.50. Write, enclosing check or money order, to Forging Industry Association, 55 Public Square, Cleveland, Ohio 44113.



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

We made a raincoat for a bee.

Not just an ordinary raincoat either.

It's a skintight plastic coat so thin you would never know it's there. Yet it covers the bee completely, right down to the individual hairs on the bee's knees. It was done to protect specimens in a natural history museum.

But we didn't spend 12 years on a new plastic just to protect bees. We developed parylene to protect things like bees —fragile, complex things so intricate in shape they are next to impossible to coat.

For instance. Each tiny grain of a highly reactive chemical can be protected to provide stability in the presence of gases or moisture. Tiny electronic capacitors, just one-fifth the size of previous types, can be insulated with a coating as thin as eighty-millionths of an inch.

Union Carbide finished the initial development work on parylene in February 1965. Until then, there was no comparable way to encapsulate delicate objects.

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THE DISCOVERY COMPAN

Thirtieth Annual Alumni Seminar

Saturday, April 22, 1967

Dinner and Evening Program

Huntington-Sheraton Hotel, Pasadena

AN AEROSPACE EXECUTIVE VIEWS
THE CHALLENGE OF INNOVATION

L. Eugene Root
President, Lockheed Missiles & Space Company

By "innovation" is meant the deliberate attempt to create new products which will affect the lives of large segments of society. As such, it is a process playing a key role in our civilization, intimately connected with the principle of free enterprise. In the context of today's aerospace industry, it is conducted in partnership with our government and directed primarily toward national safety. Innovation is essential, risky, and expensive. The industry-government partnership must show strong discipline as it is increasingly forced to exhibit technological excellence, timeliness of meeting national problems, and enlightened and early screening alternatives. These general principles will be illustrated by specific examples drawn from actual weapon system histories.

Special Lecture

Beckman Auditorium, 11:45 A.M.

DESIGNING FOR PEOPLE
(Human Factors Engineering Applied to Automobile Design)

Peter Kyropoulos
Technical Director, General Motors Styling Staff

Human Factors Engineering is a truly interdisciplinary endeavor. It combines the efforts of the engineer, industrial designer, psychologist, anthropologist, and life scientist. Just how these people work in solving the problem of man-machine-environment relationships will be illustrated in some detail.

Seminar Lectures

THE NEW GREEN THUMB
9:30 A.M. and 10:45 A.M.
Arie J. Haagen-Smit, Professor of Bio-organic Chemistry

With our rapidly increasing population, the factors affecting production of our basic food elements cannot be left to incomplete observations and individual judgment. Unraveling the factors influencing plant behavior is possible in Caltech's "Phytotron," a plant laboratory in which various climates can be reproduced. The regulation of growth processes and the adaption of plants to their environment will be illustrated with films produced by the *Encyclopedia Brittanica* at Caltech and the Los Angeles County Arboretum.

NUCLEAR POWER
9:30 A.M. and 2:15 P.M.
Jack E. McKee, Professor of Environmental Health Engineering

In recent years there has been a marked surge toward nuclear power in the U. S. and elsewhere. Nuclear reactors will soon mushroom on our landscapes. Will they be economical? Are they safe? As a member of AEC's influential Advisory Committee on Reactor Safeguards, Dr. McKee has been following these developments closely.

THROUGH A FLY'S EYE
9:30 A.M. and 2:15 P.M.
Gilbert D. McCann, Professor of Applied Science; Director, Willis H. Booth Computing Center

Important facets of research in information science are concerned with studies of the visual nervous system. There are basic similarities between the principles of sight sensory systems and those of information processing. Results obtained from insect vision research, the computer system concepts used, and new types of visual communication principles will be presented.

BBC FILM—MEN AT THE HEART OF THE MATTER
9:30 A.M. and 2:15 P.M.

This film deals with the nature of particle physics and theoretical physicists. Richard P. Feynman, Richard Chace Tolman Professor of Theoretical Physics, is featured.

CRACKED CLOCKS AND CONTINENTS
9:30 A.M. and 3:15 P.M.
Leon T. Silver, Professor of Geology

Data on the natural radioactive isotope systems U and Th found in natural mineral clocks can be organized to read the precise time of mineral formation, even when disturbed by younger geologic processes. Investigations of minerals in ancient rocks in California and adjacent areas are providing valuable information on the nature of displacements of the crust along the great fault systems of southwestern North America.

YOUR CHEATING HEART
9:30 A.M. and 4:15 P.M.
Sheldon K. Friedlander, Professor of Chemical and Environmental Health Engineering

Plastic hearts, membrane lungs, and artificial kidneys are currently the subjects of intensive research and development efforts by bioengineering groups. While some successes have been achieved with each type of artificial organ, many obstacles remain before really satisfactory designs can be produced. Some of the characteristics of these devices and the engineering problems encountered in dealing with blood flowing over the surfaces of non-biological materials will be discussed.

SURVEYOR-ING THE MOON
10:45 A.M. and 2:15 P.M.
R. J. Parks, Assistant Laboratory Director for Lunar and Planetary Projects

Surveyor I, the first American spacecraft to soft-land successfully on the moon, is the only vehicle thus far capable of photographing and measuring the effects of its landing on the lunar surface. Spectacular photographs will be viewed and discussed. Information about lunar bearing strength, soil characteristics, lunar topography, and local radio reflectivity, and their implications on the Apollo manned landing program will be covered.

IMPERIALISM, BRITISH STYLE
10:45 A.M. and 3:15 P.M.
Robert A. Huttenback, Professor of History

Historians have never agreed as to the nature of imperialism. Some of the motivations for imperial expansion, the nature of British imperialism, and the role of the imperial proconsul will be discussed. An attempt will be made to dissect the intellectual content of British imperialism, to determine whether there was a viable imperial philosophy dedicated to the betterment of man, or whether British imperialism was merely a manifestation of national ego.

BBC FILM—STRANGENESS MINUS THREE
10:45 A.M. and 3:15 P.M.

This film describes the discovery of the omega minus particle. Featured are Drs. Richard P. Feynman, Murray Gell-Mann, and Yuval Ne'eman.

NEW LIGHT ON THE UNIVERSE
10:45 A.M. and 3:15 P.M.
Wallace L. W. Sargent, Assistant Professor of Astronomy; Staff member, Mt. Wilson and Palomar Observatories

During the past 20 years enormous progress has been made in studying the universe in new regions of the electro-magnetic spectrum—in radio waves, in x-rays, and in the ultraviolet and the infrared. As a consequence, new kinds of objects have been discovered, ranging from "dark brown stars" to quasars, and new light has been shed on the problem of the large-scale structure and evolution of the universe. This talk surveys how Caltech astronomers and physicists are helping to explore these new fields.

ZANY CALIFORNIA POLITICS
10:45 A.M. and 4:15 P.M.
Robert L. Woodbury, Assistant Professor of History

Much of the nation views the political behavior of the most populous state as zany, baffling, and dominated by extremists. The characterization is not wholly mythical. Historically, California has responded to the pressures of a rapidly urbanizing society in a manner little different from the rest of the nation. Today, California may simply be the first to experience the agonies of new problems and new interest groups that will bring a new politics to other states as well.

BBC FILM—FRED HOYLE'S UNIVERSE
12:00 Noon and 4:15 P.M.

This film is concerned with cosmology and recent developments in radio and visual astronomy. Fred Hoyle, Visiting Associate in Physics, and Maarten Schmidt, Professor of Astronomy, are featured.

THEORY OF NUMBERS—OLD AND NEW PROBLEMS
2:15 P.M. and 3:15 P.M.
Tom M. Apostol, Professor of Mathematics

Speculations about the nature and properties of the whole numbers 1, 2, 3, 4, 5 . . . probably constitute the oldest form of mathematical thought. In time these speculations have grown into a vast and beautiful discipline called the Theory of Numbers, with ramifications linking it with every other branch of mathematics. This informal discussion describes some of the problems that have fascinated both professional and amateur mathematicians from ancient times to the present.

THE NEXT 90 YEARS
2:15 P.M. and 4:15 P.M.
James F. Bonner, Professor of Biology

1967 marks the tenth anniversary of the publication of *The Next 100 Years* by Drs. Harrison Brown, John Weir, and James Bonner. The book contained predictions on the course of industrial progress, material welfare, social changes, population and food problems, problems of urbanization, etc. This year's discussion reviews those projections and their accuracy to date and views the next 90 years.

WHAT IS LIFE?
3:15 P.M. and 4:15 P.M.
Robert L. Sinsheimer, Professor of Biophysics

The advances in biology of the past few decades have provided a much deeper understanding of the nature of life and its basis in molecular organization. From these concepts arise inferences and speculations concerning the origin and evolution of life on earth and, by extension, perhaps relevant to life anywhere. Considerations of the possibilities for life in other environments require us to seek new perspectives in which to view the only life we know. These concepts and quandaries will be discussed.

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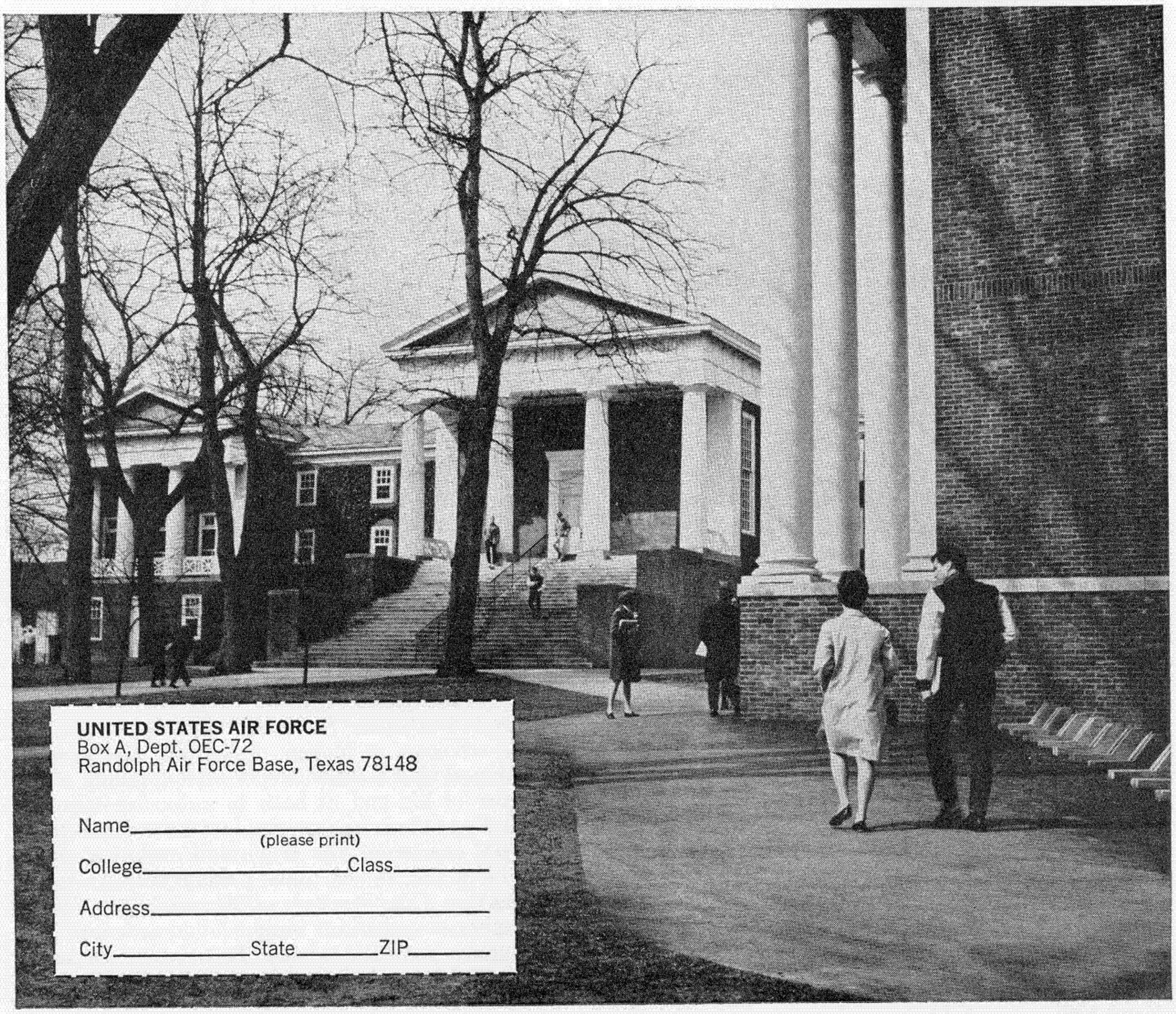

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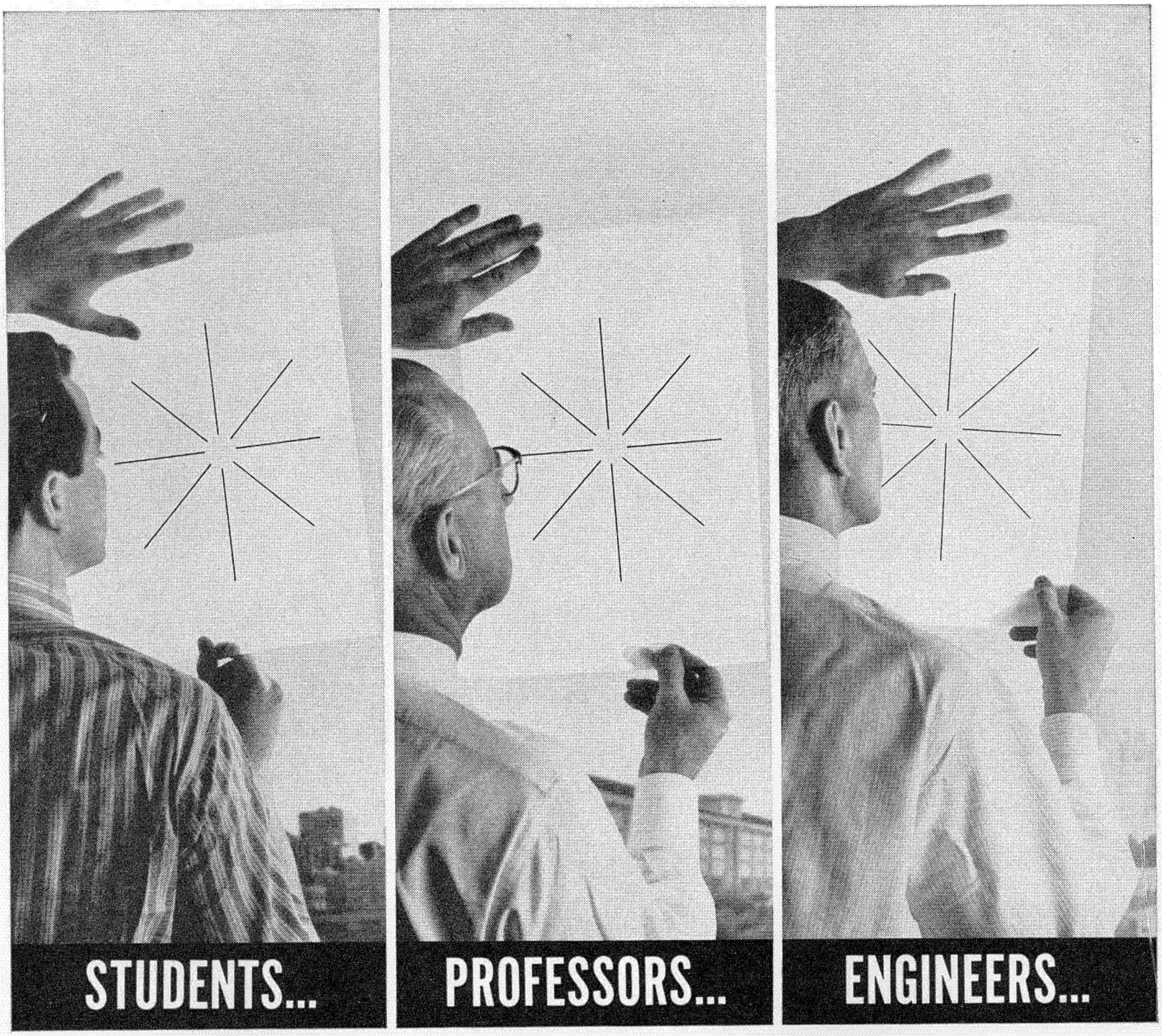

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PERSONALS

1926

ARTHUR B. ALLYNE died in Vancouver, B.C., in December at the age of 62. He was vice president and director of the Westcoast Transmission Company there. Allyne had been active in natural gas pipelining and power engineering throughout his career. When he joined Westcoast in 1960, he became a Canadian citizen. Allyne is survived by his wife, two sons, and two grandchildren.

RALPH B. BLACKMAN recently completed 40 years with the Bell Telephone Laboratories. He is a member of the mathematics and statistics research center at the company's Murray Hill, N.J., laboratory. Blackman has served on a variety of research projects, the most recent in satellite communications.

1927

THOMAS S. SOUTHWICK, MS '29, retired in January for the second time, after completing almost four years in Thailand with the World Meteorological Organization. He and his wife will sail from Singapore to Italy in March and will spend a year or two in Europe before returning to the United States.

1931

MAYNARD M. ANDERSON has been named chief engineer of the Metropolitan Water District of Southern California. He has served as chief construction engineer since 1965.

1932

GORDON E. BOWLER has been appointed to the city planning commission of Los Altos Hills, Calif.

1933

WILLIAM M. EVANS, MS, chairman of the board of the Emerson Electric Company, has been elected president and chief operating officer of U.S. Electrical Motors in Los Angeles. Evans joined the company in 1933.

JOHN C. MONNING, general manager of the Los Angeles city building and safety department, died of a heart attack this month while on reserve duty at the Army War College in Carlisle, Pa. He was 54. Monning, who lived in Pasadena, joined the city building and safety department in 1936 as a structural engineer and was appointed to the top position in 1960. He leaves his wife, Betty, and a son and daughter.

1935

ALAN BEERBOWER is a senior research associate with the Esso Research and Engineering Company in Linden, N.J.

1939

CHARLES H. TOWNES, PhD, provost and institute professor of physics at the Massachusetts Institute of Technology in Cambridge, has been elected president of the American Physical Society.

LLOYD R. ZUMWALT, PhD, has joined North Carolina State University in Raleigh as professor of nuclear engineering. Zumwalt was formerly with the general atomic division of the General Dynamics Corporation of San Diego, Calif., where he was a senior research advisor and leader of the reactor chemistry group.

1940

GORDON B. WEIR, MS '41, has been working since December as staff meteorologist for the NBC television network in Burbank, Calif.

1942

WARREN GILLETTE, MD, writes that he spent November and December in Vietnam as a volunteer physician. Stationed at the province hospital in Pleiku, he cared for Vietnamese civilians.

1946

SERGE LANG, professor of mathematics at Columbia University in New York, has been awarded the Prix Carriere for 1966, one of two prizes in mathematics awarded annually by the Institut de France. Lang was honored "for his works in geometry, algebra, and analysis." He has taught at the University of Chicago, the College de France, and Poincaré Institut in France. He has been on the faculty at Columbia since 1955.

1947

JACK E. FROEHLICH, MS '48, PhD '50, has been named president of the National Engineering Science Co. in Pasadena, Calif. NESCO, a subsidiary of the Pike Corporation of America, is engaged in marine and aerospace research and product development.

PAUL B. JOHNSON, PhD, spent January in Tanzania, Nigeria, and Liberia giving lectures for the ministry of education in each country.

NORMAN R. LEE is one of 160 business executives and government officials from the United States and several foreign countries selected to participate in the 51st session of the advanced management program of the Harvard University Graduate School of Business Administration. The session is designed to prepare executives for the leadership responsibilities required by top management positions.

ROBERT S. MACALISTER JR is working for the Shell Development Co. in Houston, Tex. As a technical staff member in the production department, he spends much of his time at scattered locations throughout the country, helping to facilitate the use of computers by engineers and geologists for analysis and problem solving.

DEAN A. WATKINS, MS, co-founder, president and director of Watkins-Johnson Company, has been elected to the board of trustees of Stanford University. A former professor of electrical engineering at the university, Watkins still lectures there.

1949

ALAN H. GREEN, MS, is a group aerodynamics engineer with Harry Kahn Associates, consultant engineers in Great Neck, Long Island, N.Y.

1950

ROBERT V. MEGHREBLIAN, MS, PhD '53, manager of the space sciences division at Caltech's Jet Propulsion Laboratory, has been elected a fellow of the American Nuclear Society.

1951

JOHN G. ELLIOTT is working on the Apollo-Saturn project for the Douglas Aircraft Company at Cape Kennedy, Fla. He is supervisor of the Saturn 1B portion of the mechanics and reliability section.

1952

DAVID L. HANNA is in Lahore, West Pakistan with Booz, Allen & Hamilton International, Inc. He is involved in management consulting projects for highways, railways, and water supply and probably will be in Lahore for another two years.

1953

DAVID JOHNSTON is the new assistant to the manager of the Western Geophysical Company's Digital Processing Center in London, England.

1954

SIDNEY B. BELLINGER JR., MD, is serving as chief of surgery at the U.S. Naval Hospital in Guam.

1956

HOWARD M. BRODY, MS, PhD '59, is associate professor of physics at the Uni-

CALTECH IS ALUMNI

"The California Institute of Technology
is no stronger than its alumni.
It deserves to exist
only if its alumni
are serving the community and the nation
in an important way—
and if it is also clear that what the alumni gained
while students at the Institute
made an important contribution
to their careers."

—LEE A. DUBRIDGE

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ALUMNI NEWS

Board Nominations

The Board of Directors of the Alumni Association met as a Nominating Committee on February 28, 1967, in accordance with Section 5.01 of the By-Laws. Eight vacancies will occur on the Board at the end of the fiscal year, June 1967. Four of these vacancies will be filled by the Immediate Past President, President, Secretary, and Treasurer, ex officio, and four will be filled by direct election. The present members of the board, with the years their terms expire are:

Donald S. Clark '29	1967	Sidney K. Gally '41	1968
Theodore C. Combs '27	1967	Robert W. Lynam '54	1967
Donald D. Davidson '38	1968	Paul D. Saltman '49	1967
Manfred Eimer '47	1968	Richard P. Schuster, Jr. '46	1967
Craig T. Elliott '58	1968	Frederic T. Selleck '49	1968
John R. Fee '51	1967	Martin H. Webster '37	1968

The following nominations have been made:

President—Frederic T. Selleck '49	(1 year)
Vice President—Donad D. Davidson '38	(1 year)
Secretary—Donald S. Clark '29	(1 year)
Treasurer—John R. Fee '51	(1 year)
Director—Fred C. Anson '54	(2 years)
Director—Horace W. Baker '35	(2 years)
Director—William F. Chapin '41	(2 years)
Director—Robert C. Perpall '52	(2 years)

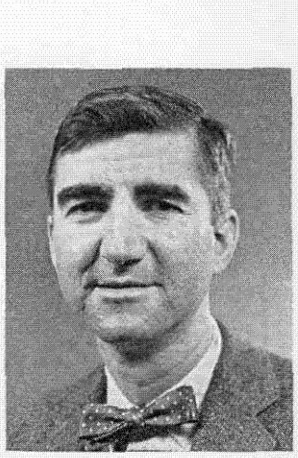
Section 5.01 of the By-Laws provides that the membership may make additional nominations for the four (4) Directors by petition signed by at least twenty-five (25) members in good standing, provided the petition is received by the Secretary not later than April 15. In accordance with Section 5.02 of the By-Laws, if further nominations are not received by April 15, the Secretary casts a unanimous ballot for the members nominated by the Board. Otherwise a letter ballot is required.

Statements about the nominees are presented below.

—Donald S. Clark, Secretary

Horace W. Baker received his BS in mechanical engineering in 1935. After his graduation he joined the firm of J. T. Thorpe, Inc., engineering contractors specializing in high temperature furnace installations. He became president of the firm in 1958. He served on the Alumni Seminar committee in 1956 and again in 1963, and last year he was a member of the alumni study group.

William F. Chapin received his BS degree in applied chemistry in 1941 and was ASCIT vice president in his senior year. From graduation until 1944 he was a process engineer at the Permanente Metals Corp. magnesium plant near Los Altos, Calif. He then joined The Fluor Corporation, Ltd., as a process engineer in Los Angeles and has remained with this engineering and construction firm since that time. From 1948 to 1957 he was chief process engineer of the Houston division; from 1958 to 1962 was manager of projects in Los Angeles; and since 1963 has been vice president of process engineering and development. In 1966 he served as a member of the alumni study group.



Fred C. Anson received his BS in chemistry in 1954 at Caltech and his MS and PhD from Harvard in 1955 and 1957. He joined the Caltech faculty in 1957 as an instructor in the division of chemistry and chemical engineering, becoming assistant professor the following year and associate professor in 1964. He has been a Fellow of the John Simon Guggenheim Foundation and is now an Alfred P. Sloan Foundation Research Fellow. His primary research interests lie in electrochemistry and electroanalytical chemistry. He is the alumni athletic representative for 1966-67.

Robert C. Perpall received his BS in mechanical engineering in 1952. He received his MS in 1956, while on leave of absence from the Garrett Corporation. In 1960 he joined the Cosmodyne Corporation as senior project engineer and subsequently became vice president of the La Fleur Corporation. In 1962 he rejoined the Garrett Corporation as part of the Apollo Program. He is now system engineer on the C-5 Environmental Control System. This year he is general chairman of the Alumni Seminar, having served as assistant program chairman in 1966 and as a member of the program committee in 1964 and 1965.

Personals . . . *continued*

versity of Pennsylvania in Philadelphia.

ROBERT C. KAUSEN is product manager of adhesives for the Narmco Materials Division of the Whittaker Corporation in Costa Mesa, Calif.

1960

SAMUEL BERGMAN is a doctoral candidate at the University of Pennsylvania in Philadelphia, studying computer and information science.

VLADIMIR A. HVOSCHINSKY, MS, is a project leader at the Lockheed Missiles and Space Company in Palo Alto, Calif., working on radiometer terminal missile homing independent development.

THOMAS H. TEBBEN has joined the San Francisco office of Arthur Anderson and Company as an operations research consultant.

1963

JOHN C. ALLEMAN, a graduate student in linguistics at Columbia University in New York, plans to study in Hungary next year on a fellowship from the Inter-University Committee on Travel Grants.

1966

JOHN S. MURRAY JR., MS, is employed as an engineer-scientist with Hughes Aircraft of Culver City, Calif.

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Sidney K. Gally, '41

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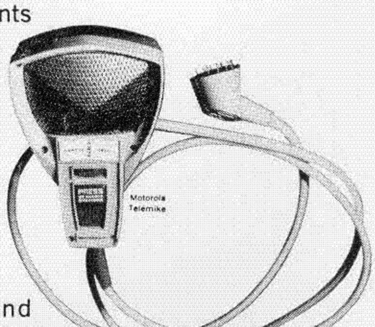

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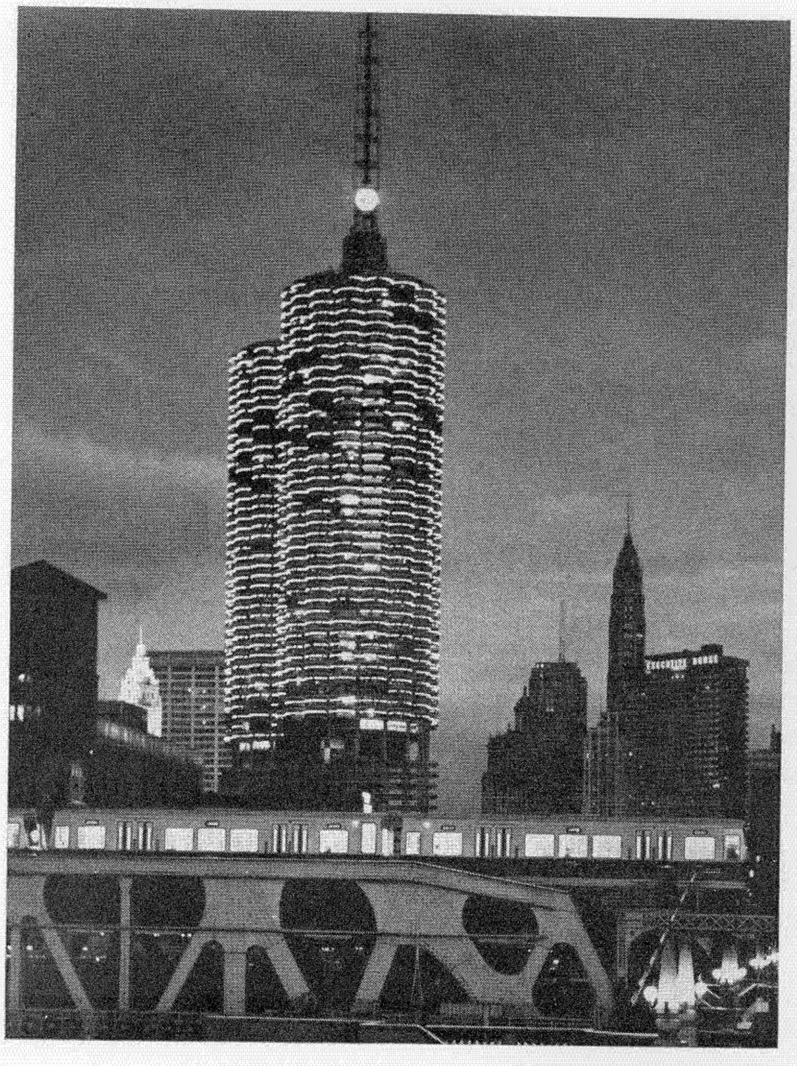

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